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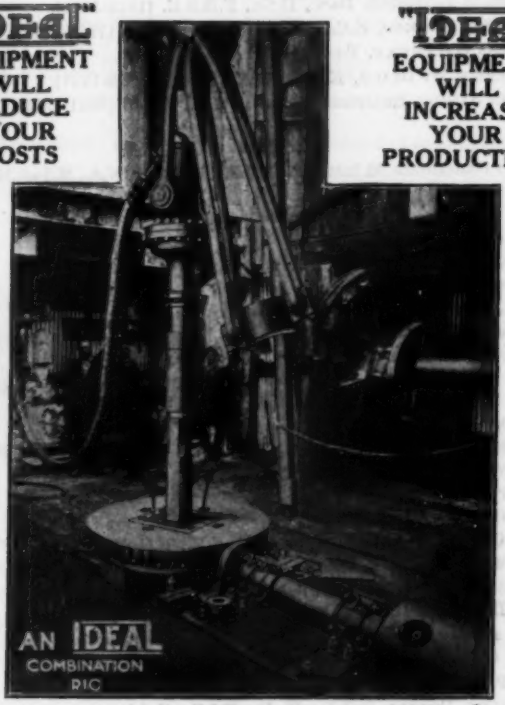

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Issue of Journal. The Journal is published in six bi-monthly parts per volume, viz., February, April, June, August, October and December. A brochure giving the History, Regulations and List of Members of the Institution was published in January, 1923, and the revised List of Members will be published periodically.

All members receive these publications free of cost. Additional copies of the Journal are charged at the rate of 7s. 6d. per part, and of any other publication at the price stated on the wrapper.

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English equivalents of foreign weights and measures should be given, and it is suggested that a bibliography of the subject dealt with be appended.

All papers and articles submitted are assumed to be original communications unless otherwise stated, in which case reference to the previous publication should be given.

Members are invited to submit papers to be read at the General Meetings of the Institution, and are specially asked to forward articles for publication in the Journal.

* * * *

Members desiring to receive advance galley proofs of papers to be read before the Institution should apply to the Secretary, informing him of the address to which the proof is to be sent.

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This notice applies to all previous volumes.

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Orders for extra reprints should be sent to the printers when the manuscript is forwarded to the editor.

Bibliography and Abstracts. A bibliography of current literature is published with each issue of the Journal, together with abstracts of the more important articles and patent specifications, this supplement being paged separately to the Transactions. In order to make this section of the maximum value, members are requested to send any matter which may have been inadvertently overlooked to the editor.

Medal for Student Members. A medal and a prize of five guineas will be awarded annually by the Council to that Student Member of the Institution who shall, in their opinion, have presented a paper of outstanding merit during the year.

Advertisements. A number of Advertisements are inserted in the Journal, and information as to terms, etc., can be obtained from Mr. R. Donald Elcox, Advertisement Manager, Journal of the Institution of Petroleum

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Appointments Register. A register of members requiring appointments is kept at the office of the Institution for the convenience of firms requiring the services of petroleum technologists, etc., it being understood that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library may be consulted between the hours of 11 a.m. and 4 p.m. daily. The additions made to the current and standard literature on petroleum and allied substances, since the publication of the last Journal, are :—

El Petroleo y Comodoro Rivadavia. By Capt. F. Fliess.

The Oilfields of the Argentine Republic and the Argentine Oil Industry. By Campbell M. Hunter, O.B.E.

From the Chemical Catalogue Co. (*For review*) :—

Motor Fuels : Their Production and Technology. By Eugene H. Leslie, Ph.D.

From the Geological Survey of India :—

Records of the Geological Survey of India, Vol. 54, Part I., 1922.

From the Universite de Strasbourg :—

Bulletin du Laboratoire du Petrole, December, 1922.

From the Diesel Engine Users' Association :—

Report on Heavy-Oil Engine Working Costs, and Report of Discussion.

From the Joint Matriculation Board :—

Syllabus of the Matriculation Examination conducted by the Joint Board of the Universities, Manchester, Liverpool, Leeds, Sheffield, and Birmingham, 1924.

From the Institution of Mechanical Engineers :—

Proceedings of the Institution of Mechanical Engineers, Vol. 2, 1922.

From the American Institute of Mining and Metallurgical Engineers :—

Directory of the American Institute of Mining and Metallurgical Engineers, corrected to April 7th, 1923.

From the British Engineering Standards Association :—

Complete set of Specifications to date.

From the Imperial Mineral Resources Bureau :—

Fourth Annual Report of the Governors of the Imperial Mineral Resources Bureau, 1923.

From the Department of Mines, Canada :—

Bulletin No. 579. Titanium. By A. H. A. Robinson.

From the U.S. Bureau of Mines, Department of the Interior :—

Serial No. 2462. The Treatment of Natural-Gas Gasoline to meet the Doctor Test. By D. B. Dow. April, 1923.

List of the Publications of the Bureau of Mines. August, 1921.

Bulletin No. 163, Petroleum Technology, No. 46. Methods of Shutting off Water in Oil and Gas Wells. By F. B. Tough.

Bulletin No. 170, Petroleum Technology No. 48. Extinguishing and Preventing Oil and Gas Fires. By C. P. Bowie.

Technical Paper No. 216. Vitiation of Garage Air by Automobile Exhaust Gases. By B. A. Burrell and A. W. Ganger.

Technical Paper No. 247, Petroleum Technology No. 55. Perforated Casing and Screen Pipe in Oil Wells. By E. G. Wagy.

Technical Paper No. 253. Effects of Gasoline Removal on the Heating Value of Natural Gas. By Donald B. Dow.

From the U.S. Geological Survey, Department of the Interior :—

Professional Paper No. 122. Copper Deposits of the Tyrone District, New Mexico. By Sidney Paige.

Bulletin No. 720. Economic Geology of the Summerfield and Woodsfield Quadrangles, Ohio. With descriptions of Coal and other Mineral Resources, except Oil and Gas. By D. Dale Condit.

Bulletin No. 727. Potash in the Greensands of New Jersey. By G. R. Mansfield.

Bulletin No. 737. Manganese Deposits of East Tennessee. By G. W. Stose and F. C. Schrader.

Water-Supply Paper No. 479. Surface Water Supply of the United States, 1918. Part IX., Colorado River Basin. By Nathan C. Grover, and others.

Gold and Silver in 1921, General Report. By J. P. Dunlop.

Stone in 1921. By G. F. Loughlin and A. T. Coons.

Cement in 1921. By Belle W. Bayley.

Natural-Gas Gasoline in 1921. By E. G. Sievers.

Gold, Silver, Copper, Lead, and Zinc in New Mexico and Texas in 1921. By Chas. W. Henderson.

Gold, Silver, Copper, Lead, and Zinc in Colorado in 1921. By Chas. W. Henderson.

The Council would be grateful to members, who are authors of books on petroleum or allied substances, if they would kindly present a copy of their works to the Library of the Institution, and for review in the Journal.

PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that members send information regarding their movements to the Secretary, for insertion under this heading.

Mr. GEORGE GORDON-THOMAS has been appointed General Manager of the "General Petroleum Company of Trinidad, Limited, and Reduced," and sailed to take up that appointment on April 21st.

Mr. F. E. CHERRY has returned from Colombia.

Mr. A. FRANK DABELL has proceeded to Rumania.

Mr. A. P. CATHCART has returned home from Trinidad.

Mr. C. O. CONDRUP has returned from Trinidad.

Mr. H. F. MOON has returned to England from Argentina.

Mr. T. ROBATHAN has left for Peru.

Captain T. A. PAISH has returned from Mexico.

Mr. C. E. CAPITO is on his way home to England from Bagdad.

Mr. B. G. BANKS is sailing for Trinidad on June 16th.

We have received from the Diesel Engine Users' Association a brochure, entitled "The Use of Cooling Water for Diesel Engines," by J. N. Griffin, M.I.E.E. An abstract of this appears on page 150A of this number of the *Journal*, and copies of the complete paper may be obtained from the offices of the Association, 19, Cadogan Gardens, London, S.W. 3, at a price of 3s. 0d.

We acknowledge with thanks the receipt of two numbers of the Journal of the Faculty of Engineering of the University of Tokio, which contain papers on the purification of pure naphthenic acids, by Yoshio Tanaka and Shoichiro Nagai.

JOURNALS Nos. 9, 27, 29 and 30.

As enquiries are being received for these Journals, which are now out-of-print, the Secretary would be glad to hear from members who may be desirous of disposing of any of these issues, and will put them into communication with the enquirers.

STUDENTS' SECTION.

A meeting of Student Members of the Institution was held at 5, John Street, Adelphi, London, W.C. 2, on Tuesday, May 29th, 1923, the number present being seventeen.

Mr. Arthur W. Eastlake, who occupied the chair at the beginning of the meeting, made a brief speech, welcoming the students, and Mr. H. G. Austin was then appointed as chairman of the meeting.

It was decided that the section should be known as "The Institution of Petroleum Technologists, Students' Section, London," and the following were elected to act as the Committee: Messrs. F. E. J. Foxall-Smedley, H. S. Garlick, C. O. Graham, F. R. S. Henson, A. B. Miskin, R. F. Owen, and M. Stern, the election of a Permanent Chairman being deferred until a later date.

Mr. H. G. Austin has kindly consented to act as Honorary Secretary to the section.

THE NEW OFFICES OF THE INSTITUTION.

After June 24th next the Institution will be in occupation of its new offices at Aldine House, Bedford Street, Strand, London, W.C. 2, where a floor area of 2300 square feet has been obtained, as against the 600 square feet of the John Street premises, the general arrangement of the rooms being :—

Council and Committee Room, and Secretary's Office, with an area of about 400 square feet.

An L-shaped room, of about 300 square feet area, to be used as a General Office.

The Library, having an area of about 600 square feet, being in a separate room, will ensure that in future Council and Committee Meetings will in no way interfere with those desirous of consulting books.

A Members' Room, suitably furnished, will be available so that members can meet without disturbing those using the library. This room will also be available for meetings where only a small attendance is expected.

The moving into the new premises, which are being re-decorated throughout, will commence on June 21st, and it is hoped to have them open for the use of members by June 27th. As intimated in the last Journal, the offices of the Institution will be closed between these two dates.

CURRENT PETROLEUM NOTES.

The receipt of notes of interest for insertion under this heading will be welcomed by the Editor.

It is interesting to note that while the total world's production of petroleum as recorded from 1857 to 1922 has amounted to some 322,458,000,000 imperial gallons, its volume is only equivalent to 0.38 cubic mile, or 6152 cubic acres. A tank 30 feet in height would require to have a diameter of about 9.5 miles to contain this amount, and if the whole of Hyde Park and Kensington Gardens (630 acres) were enclosed it would be necessary to build a wall 2020 feet in height to retain the total world's production.

According to the United States Bureau of Mines, 311 refineries were operating in the United States on December 31st, 1922, with an aggregate daily capacity of 1,900,560 barrels of crude. The plants were working at 79.28 per cent. of their capacity, as compared with 72.85 per cent. for the previous year.

The output of gasoline during 1922 was 6,202,234,613 U.S.A. gallons, an increase of 20 per cent. over 1921; the production of kerosene (2,306,326,489 U.S.A. gallons) exceeded that of 1921 by about 360,000,000 gallons; gas and fuel oil showed an increase of 11 per cent., amounting to 10,706,226,570 gallons; while the output of lubricating oil was 978,752,469 gallons.

Bulletin No. 201 of the United States Bureau of Mines states that the deepest rotary-drilled oil wells are in California, where it is common practice to drill with the rotary system to depths of over 4000 feet. One well in the Kettleman Hills, King's County, reached 6602 feet, and Packard Well No. 11, in Kern County, was drilled to 6240 feet with rotary tools.

It is understood that the State boring at Roma, Queensland, in which natural gas was struck at a depth of 3705 feet in 1919, but was subsequently shut-off by the influx of water under high pressure, is to be abandoned.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

THE SEVENTIETH GENERAL MEETING of the Institution of Petroleum Technologists was held in the Theatre of the Royal Society of Arts, John Street, Adelphi, London, W.C. 2, on Tuesday evening, April 10th, 1923, the President, Mr. H. Barringer, M.Inst.C.E., M.I.Mech.E., M.I.N.A., occupying the Chair.

The following Paper was read :—

POTRERO No. 4.

A History of One of Mexico's Earliest and Largest Wells.

By A. E. CHAMBERS, A.M.Inst.C.E. (Member).

POTRERO No. 4 is well known as one of the largest of the enormous producers of Mexico, having given over one hundred million barrels of oil before salt water appeared. Its technical history is less known, only occasional paragraphs regarding it having been published in the petroleum press, and it is in the hope that a detailed description of the chief events in the life of this well will be of interest to the members that this paper is presented to the Institution.

The career of the well was an eventful one; it was brought in uncontrolled in December, 1910, brought under control in March, 1911, developed large seepage areas in its vicinity early in 1914, caught fire in August of that year, was extinguished early in April, 1915, produced under partial control for nearly four years, until December, 1918, when its production turned to an emulsion, which continued until April, 1919, when the well was finally closed in.

The well is situated in the State of Vera Cruz, some 50 kilometres North-West of the town of Tuxpam. The exact site for drilling was placed about 20 metres from the banks of a small river called the Buena Vista; this stream joins the main Tuxpam River at a distance of some 25 kilometres from the well.

The decision to drill was made in April, 1910, drilling began on the 9th June, and a depth of 1856 feet was reached by July 23rd. Operations were then stopped until December 23rd, when drilling

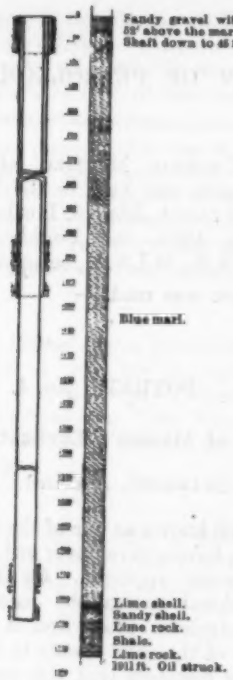


FIG. 1.

POTRERO No. 4 WELL—SUMMARY OF LOG.

Week ending.	Present depth.	Formation.	Progress.	Average daily progress per week.	Average daily progress since commencement.
1910. June 11th	Ft. 35	Blue marl	Ft. 35	Ft. in. 11 8	Ft. in. 11 8
June 18th	400	„ „	365	52 2	40 0
June 25th	835	„ „	435	62 1	49 1
July 2nd	1127	„ „	292	41 8	46 11
July 9th	1473	„ „	346	49 5	47 6
July 16th	1755	„ „	282	40 3	46 2
July 23rd	1856	Lime rock	101	14 5	41 3
Well shut down from July 23rd to Dec. 23rd.					
Dec. 27th	1911	Lime rock	55	11 0	38 2

was recommenced. Oil was struck at 2 a.m. on the 27th December, 1910. Fig. 1 shows a diagrammatic section of the well and an abstract of the log. It will be observed that the drilling was accomplished without difficulty, and the arrangement of casings was such as was usual in those days.

At the time oil was encountered, no drilling valve was on the well head; instructions had been given to instal such a valve, but had not been carried out by those in charge of the drilling. It should be mentioned, however, that for days previous to the well coming in there had been no signs of oil and gas where both had been expected, and it may be said that the use of drilling valves was, in those days, not by any means the universal practice that it has since become in the Mexican fields.

When oil was struck the bailer was being used; this was thrown clear of the well, and the oil rose to a height of some 250 feet, whilst spray and gas went considerably higher. Vegetation for a radius of about a mile quickly became covered with oil. Fire was obviated by the presence of mind of the driller, who scrambled in the darkness through the thicket by the only way left open to the boilers and shut off the oil burners. Fig. 2, a reproduction from a photograph, gives some idea of the appearance of the well at the time.

The specific gravity of the crude oil was 0·931° at 60° F., its temperature at the well was 147° F., and the pressure when the well was closed in was found to be 825 lbs. per square inch.

At first all endeavours were devoted to saving the oil, but it was soon apparent that the quantity being produced was too great to attempt storing it; a careful calculation made on December 29th showed that the well was then flowing at the rate of over 100,000 barrels in 24 hours. The Buena Vista River, previously mentioned, is the natural drainage for the area where this well is situated, and it was down this stream that immense quantities of oil flowed and were burnt many kilometres away.

It was evident that the only thing to do to save this well and its production was to bring it under control. Owing to the great pressure and volume of oil no ordinary method could be used, and several schemes were suggested; finally, however, an appliance, now fairly well known under the name of a "Bell Nipple," was devised and successfully installed on January 25th, 1911. The well was not entirely closed, as there was some doubt as to the advisability of doing this, mainly owing to the weakness of design of the "Bell Nipple" device, which it had been necessary to make hurriedly from locally obtained material. A stronger design was made and successfully applied to the well on March 31st, 1911; and those in charge were enabled to entirely close in

production. In the meantime, earthen storage to the extent of three million barrels had been made and was almost entirely filled.

Fig. 3 shows the details of the capping device. It will be observed that, when the well came in, the well head was fitted with a 10-in. to 8-in. swedge nipple screwed on to the 10-in. casing with a piece of 8-in. casing some 3 ft. 6 in. long having a collar on its upper end, screwed into the swedge nipple. As will be seen from the diagram, the device consisted of a bell-shaped mild steel nipple with a tee-piece and valves flanged to its smaller end, the bell being so designed that, when forced down on to the well head, in this case the 8-in. collar on the small piece of 8-in. casing, it made a metal-to-metal joint. The bell nipple was mounted on two $2\frac{1}{2}$-in. diam. steel rods hinged to clamps, which on this well were securely bolted on the 10-in. casing. As an additional precaution the 10-in. clamps were bolted to another clamp placed on the 13-in. casing. As shown on the diagram, the hinges permit of the whole apparatus being mounted in a more or less horizontal position, out of the way of the direct flow of the well. When the appliance had been made ready in a horizontal position it was gradually raised, with the top valve open, into a vertical position directly over the well head. This was accomplished by means of small winches placed some 200 yards from the well, one winch hauling up and the other paying out until the whole appliance was vertically over the well, and the oil flowing through it. Long-arm ratchet spanners were attached to the nuts shown on the upper end of the rods, and, by means of ropes attached to these spanners, operated some 20 yards away, the nuts were turned, gradually forcing down the bell nipple until it finally made joint with the 8-in. collar. When this was done the top valve of the bell nipple was slowly closed, the valve, on the branch which had been connected to storage, having been opened. This branch valve was subsequently shut and the well entirely closed in. Guys were then attached to the top of the rods, securing the whole apparatus in a vertical position, the winches then being removed.

A 6-in. and an 8-in. flow-line were connected from the valve on the branch of the tee-piece to the storage tanks, a distance of some 800 metres. One of these lines was subsequently disconnected.

It is difficult for anyone who has not seen wells of this nature to realise the conditions under which an operation such as this was conducted; the workers at the well were continually in an almost blinding deluge of asphaltic oil; the roaring of the oil gushing out entirely prevented one making oneself heard, and, indeed, induced partial deafness for a time, whilst the suffocating

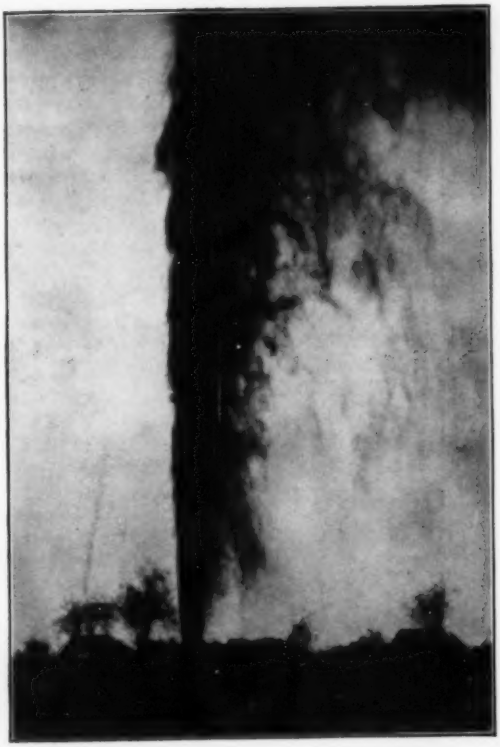


FIG. 2.

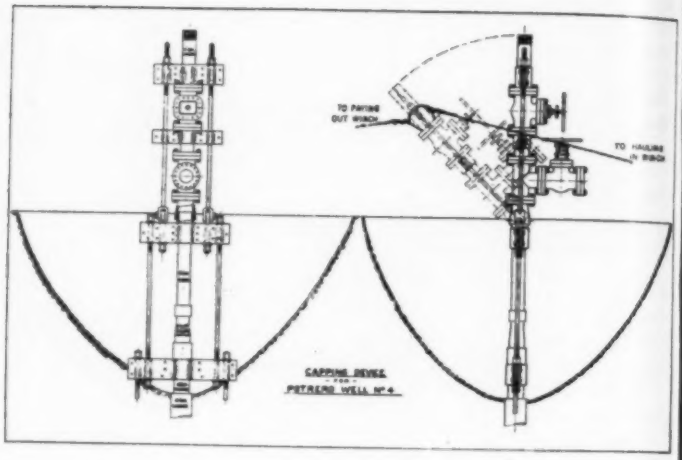

TO PAYING OUT WINCH
TO HAULING IN WINCH
CAPPING DEVICE
FOR
PETREBO WELL Nº 4

FIG. 3.

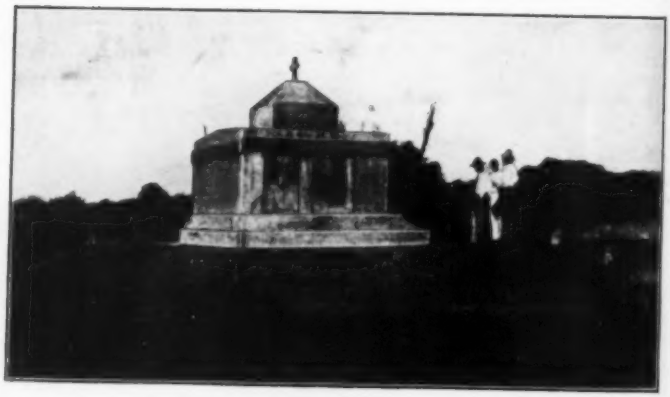


FIG. 4.

gases given off from the oil made working impossible for more than a few minutes at a time in the vicinity of the well. Another effect of the gas is to produce an extremely painful inflammation of the eyelids, which few escape. Above all other troubles there was the constant danger of fire, either malicious or accidental, to be apprehended. When it is recalled that this was the first big Mexican "wild" well to be controlled, that no appliances had yet been designed for shutting them in, and that there were no men available experienced in such work, one cannot but admire the courage and pertinacity displayed. Nowadays there have been quite a number of such wells out of control from one cause and another, and experience has made dealing with them, whilst still dangerous and difficult, a comparatively simple matter.

The author is under an obligation for some of the details of the bringing in of this well to Mr. Robert Stirling, Member of the Institution, who at this time had just taken up the management of the oilfields. Mr. Stirling has told the writer that the idea of the bell nipple originated with one of the drillers who had seen an appliance of a somewhat similar nature successfully used on small wells in the United States, but that the scheme of clamps and hinges to overcome the difficulty of forcing down the bell nipple against the great pressure of this well was evolved at Potrero.

Mr. F. C. Lawrie was responsible for carrying out the design of the "Bell Nipple," and, with Mr. S. Weaver, took charge of shutting-in the well with it.

Lord Cowdray, a Vice-President of this Institution, who was in Mexico at the time, directed generally the operations at Potrero until the first bell nipple was successfully placed on the well; those who have had the privilege of working in contact with him will realise how much his presence contributed to the outcome of the work.

The well produced from the time it was controlled until August, 1914, a period of two years and five months, to meet the requirements of the Pipeline Department, a valve at the well head being opened and shut as was necessary to effect this.

In order to safeguard the well to some extent a small concrete house was built over the well head, steam pipes were put into the interior of the house so that in times of lightning storms the well head could be completely surrounded by steam.

In November, 1913, revolutionary conditions in Mexico became rather bad, and the possibility of the well being set on fire or blown up by one or other of the parties of rebels which were continually pervading the district became very great, and those in charge of

the well decided to fill in the small house previously mentioned with reinforced concrete, leaving merely an aperture through which the valve spindle could be worked. This was carried out, and the edifice surrounding the well was such as to make it impregnable against any ordinary charges of dynamite or other explosive, and extremely difficult to put on fire. Fig. 4 shows the concrete house built over the well.

At this time active seepages began to be observed over a large area in the neighbourhood of the well; these seepages gave a

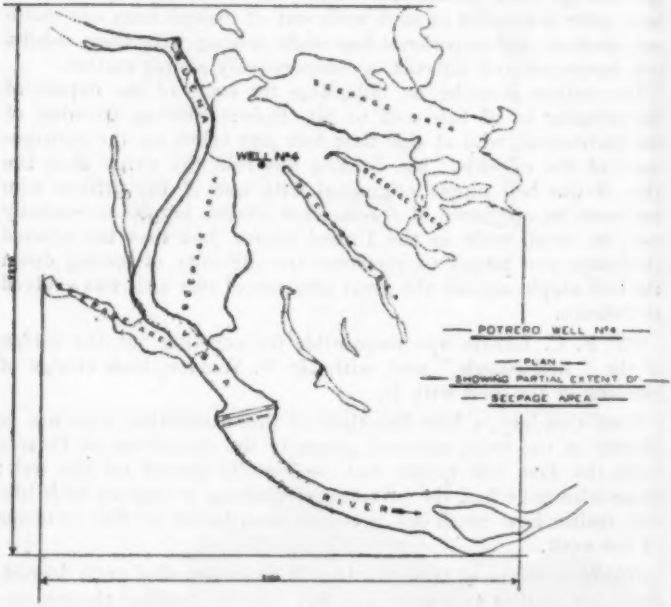


FIG 5.

continually increasing quantity of oil and gas, the oil being only slightly heavier than the crude oil produced directly from the well. Two theories were propounded to account for this development, one being that the exploitation of the well had so disturbed subterranean conditions that the oil was finding its way up from the bottom of the well, possibly some distance on the outside of the 8-in. casing, and thence distributing itself through some porous stratum and up to the surface through cracks and fissures in the overlying shale;

the second theory was that the oil coming to the top of the well through the 8-in. string forced itself down between the 8-in. and the 10-in. casing and then found a way from the bottom of the 10-in. to a porous stratum and thence to the surface. Fig. 5 shows to some extent the area of the seepages at this time.

By referring to Fig. 3 it will be noticed that the well was capped by the bell nipple being forced on to an 8-in. collar connected with the 10-in. string by an 8-in. to 10-in. swedge nipple, the 8-in. string being free inside the 10-in. and the end of it probably just inside the lower end of the swedge nipple. There was thus a practically clear passage for the oil to find its way to the bottom of the 10-in. string, and as this seemed to be the most probable origin of the seepage oil, an appliance was designed to shut off this flow of oil. The device consisted of a lead packer to be introduced through the upper valve on the well-head. It was proposed to flange on to the valve, when shut, a long cylindrical chamber having at its upper end a stuffing box through which the spindle on which the packer was mounted could be inserted into the well. It was apparent, however, that to instal this device, it would be necessary to remove all the reinforced concrete that had been recently put round the well-head. This was taken in hand and was almost completed, and a derrick was built over the well to handle the packing device referred to. Unfortunately the device could not be used owing to the fire to be subsequently described.

At about this period it was noticed that the leakage of both oil and gas from the bell nipple had increased somewhat, due, it was thought, to the operations of placing and removing the reinforced concrete.

On August 14th, 1914, a severe lightning storm visited the neighbourhood, and set fire to the gas escaping from the well; this gas fire melted some lead gaskets in the joints of the flow-line near the well-head. The oil from these joints caught fire, also the oil leaking from the bell nipple; the fire rapidly spread to the seepages, and very quickly this large area was completely involved. It was unfortunate that the occurrence coincided with a period of great revolutionary activity and when the American Government had actually advised its nationals to leave Mexico. Practically all the skilled American oilfield workers had therefore left Potrero, leaving operations in charge of a small number of British and other nationalities. These few men were inadequate to deal with the fire in its early stages, and before others could get on the scene the fire had assumed enormous proportions.

One of the effects of the fire was to cause considerable leakage at the bell nipple; why this was it is difficult to say, but it was

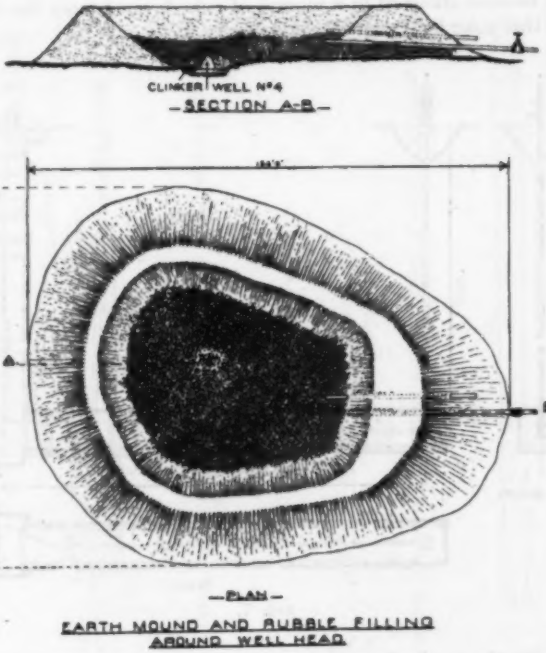
possibly due to the distortion of the rods and guys owing to the intense heat. The flanged joints at the valves, both on the bell nipple device and on the flow-line, also started to leak and added their share to the fire. Measurements made after the fire was extinguished showed that the total leakage from the well-head, that is from the bell nipple, from flanged joints and other connections, amounted to a total of over 18,000 barrels daily. The flow-line from the well to the storage tanks had been buried a short distance from its connection to the well up to the storage tanks, and through this line the well produced 20,000 barrels a day uninterruptedly throughout the duration of the fire, the passage of the oil, no doubt, keeping the pipe cool enough where it passed through the fire to prevent it being materially damaged.

Immediate steps were taken to combat the fire; batteries of some 60 steam boilers were erected in the vicinity, and steam pipes led as close as possible to the fire. A large quantity of chemicals for making a foam-producing mixture were expressed from the United States. At the same time a large body of Mexican workmen had been secured, and operations were started, having in view the limiting of the area of the fire by means of earth banks. The seepage fires were dealt with one by one, and by means of earth banks, water and steam, were all extinguished within the first few weeks' work. An earth bank was also started round the main fire at the well. Owing to the huge amount of oil burning and the intense heat, the area enclosed by the bank at first was approximately 36,000 sq. yards. Gradually, however, by taking advantage of the varying directions of the wind, and by the use of water and steam jets, the limits of the earthen bank were little by little pushed in and the height raised to about 18 feet. The fire was thus enclosed within an irregularly shaped crater, and it was decided to make an attempt to extinguish it by the use of quantities of foam-producing material, assisted by the full capacity of the steam and water plant.

The effect of reducing the area of the fire had reduced the amount of oil being burnt, and to prevent the oil level rising and overflowing the banks of the crater, a number of pipes had been placed at various positions in the earthen bank, and a considerable quantity of oil was being drawn off through them unburnt and pumped to storage.

All preparations were made to pump large quantities of foam mixture rapidly into the crater, steam and water pipes were also installed round the edge of the crater, and, at a given moment, steam, water and foam mixture were poured on top of the burning oil. The attempt, however, was quite unsuccessful, mainly owing

to the immense quantities of gas being given off from the well. This gas it proved impossible to extinguish; and although there was a considerable temporary diminution of the area of the burning oil, it soon was burning with its usual violence after the almost momentary effects of the foam mixture had subsided. It was deemed useless to make a further attempt to extinguish the fire by the use of foam, and it was decided to still further reduce the size



EARTH MOUND AND RUBBLE FILLING AROUND WELL HEAD

FIG. 6.

of the crater by pushing in the banks, to fill in the crater with rubble to a considerable height, and, by the insertion of more pipes through the walls of the crater, withdraw such quantities of oil that only gas should remain burning on top of the level of the rubble. The rubble was also effective in preventing the burning oil, issuing under pressure from the different leaks in the well head, jetting up into the air. These operations were carried out, and in about 24 weeks from the outbreak of the fire it had been controlled

to the extent that only gas was being burnt. Fig. 6 gives an idea of the dimensions of the mound and crater.

It is interesting to recall that in the early stages of the fire grave fears were entertained that the intense heat would so weaken the rods securing the bell nipple to the casing underneath that the pressure of the well would blow the bell nipple off and thus leave the well uncontrolled. It is fortunate these fears were not realised, as, evidently in the early stages of the fire, the whole of the well head became enclosed in a mound of coke formed from the burning oil; this coke held everything securely in place.

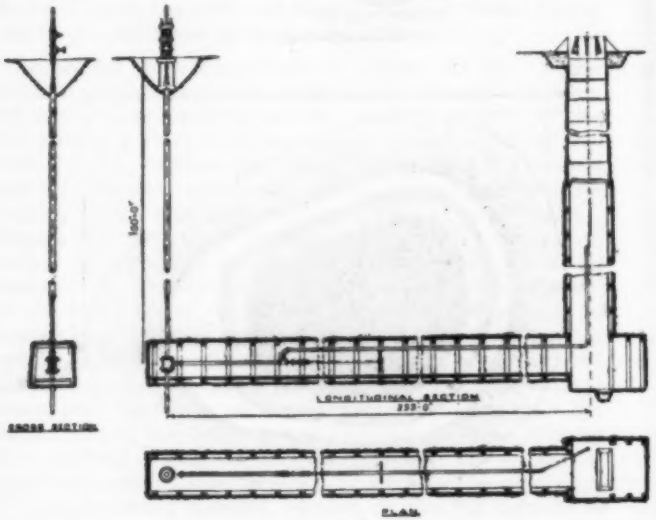
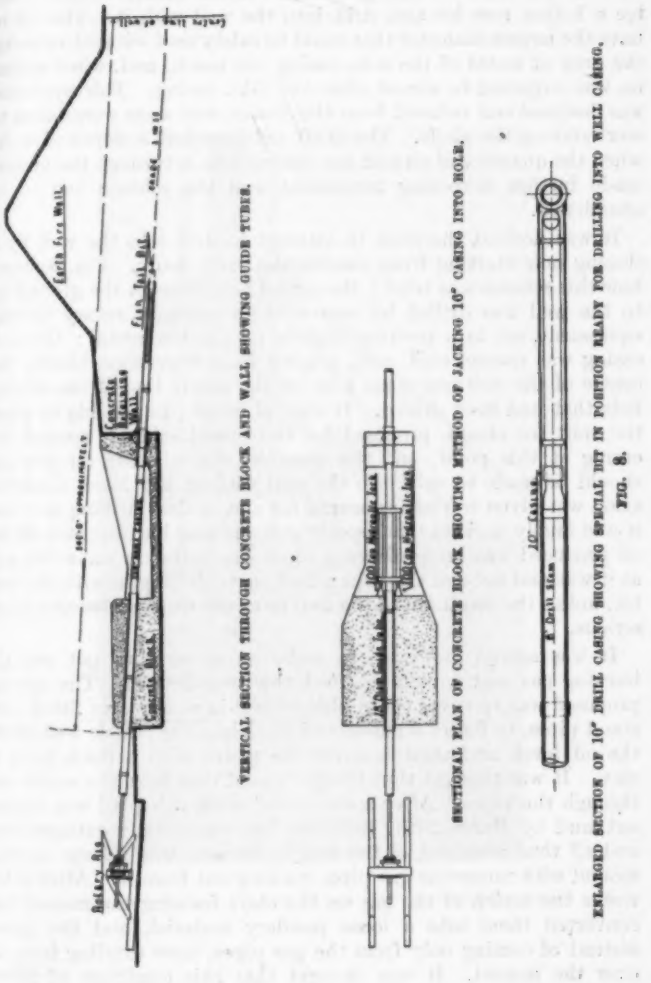


FIG. 7.

Whilst the work of controlling the fire by earth banks was being carried out many other schemes for shutting in the well had been considered; the most favourable one appeared to be an adaptation of the tunnel scheme which had been used for extinguishing a gas well in the Caddo field in the United States. The arrangements as proposed to be used at Potrero are in outline shown in Fig. 7. As will be observed, they consist in sinking a 10-ft. shaft at a distance of about 100 metres from the well to a depth of about 100 metres, and from that depth tunnelling in horizontally to the well, placing around the casing at the point where it was encountered a split



VERTICAL SECTION THROUGH CONCRETE BLOCK AND WALL SHOWING GUIDE TUBES.

SECTIONAL PLAN OF CONCRETE BLOCK SHOWING METHOD OF JACKING 10" CASING INTO HOLE.

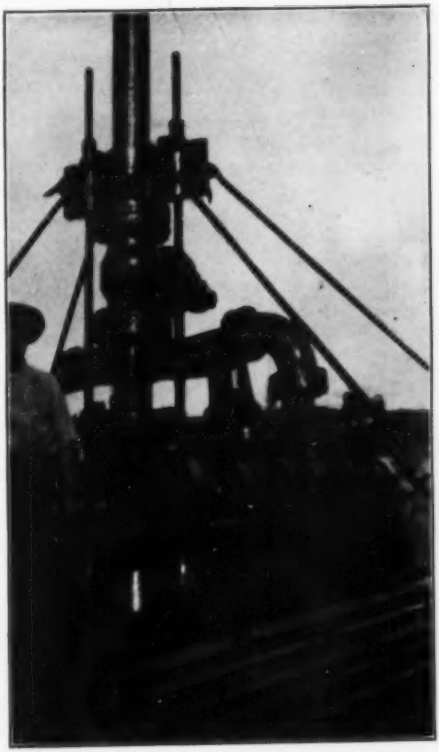
ENLARGED SECTION OF 10" DRILL CASING SHOWING SPECIAL BIT IN POSITION READY FOR DRILLING INTO WELL CASING.

FIG. 8.

cast steel tee clamp with stuffing boxes top and bottom, and after this was fixed on the casing, to insert in the middle orifice of the tee a hollow rose bit and drill into the well with it. The bit to have the largest diameter that could be safely used without reducing the area of metal of the 8-in. casing too much, and, when drilled in, was expected to almost close the 8-in. casing. This appliance was designed and ordered from the States, and steps were taken to start sinking the shaft. The shaft only reached a depth of 60 ft. when the quantity of oil and gas coming into it through the ground made further deepening impossible, and the scheme had to be abandoned.

It was decided therefore to attempt to drill into the well by a sloping hole starting from outside the earth bank. Fig. 8 shows how this scheme was tried; the actual hole through the ground up to the well was drilled by means of an ordinary rotary drilling equipment, set in a position slightly off the horizontal; the well casing was encountered, and, judging from impression blocks, the centre of the well was some 4 in. off the centre line of the sloping hole that had been drilled. It was, of course, impossible to place the split tee clamp, proposed for the tunnel scheme, around the casing at this point, and the question was whether an attempt should be made to drill into the well without it. Much consideration was given to the arguments for and against drilling in; and it was finally decided that as only gas was now burning and all the oil produced was being disposed of, it was better to leave the well as it was and not run the risks attaching to drilling in with the rose bit, unless the condition of the well or of the seepages became more serious.

It was agreed, however, to make an attempt to put out the burning gas and a plan to effect this was devised. The scheme proposed was to cover the rubble with thin steel plates fitted with stand pipes, to insert a number of pipes into the rubble well above the oil level, and then to cover the plates with a thick layer of clay. It was thought that the gas would thus take the easier exit through the pipes. After some weeks' work this plan was carried out, and by March 24th, 1915, the fire was totally extinguished, and all that remained of the well to be seen was a large earthen mound with numerous gas pipes sticking out from it. After a few weeks the action of the gas on the clays forming the mound had converted them into a loose powdery material, and the gases, instead of coming only from the gas pipes, were exuding from all over the mound. It was thought that this condition of affairs should not be allowed to remain, as, if through lightning or any other cause, the gases became ignited, it was difficult to feel certain that some serious damage might not eventually occur. The whole



VIEW OF CAPPING DEVICE AND FLOW LINE CONNECTIONS.

FIG. 9.

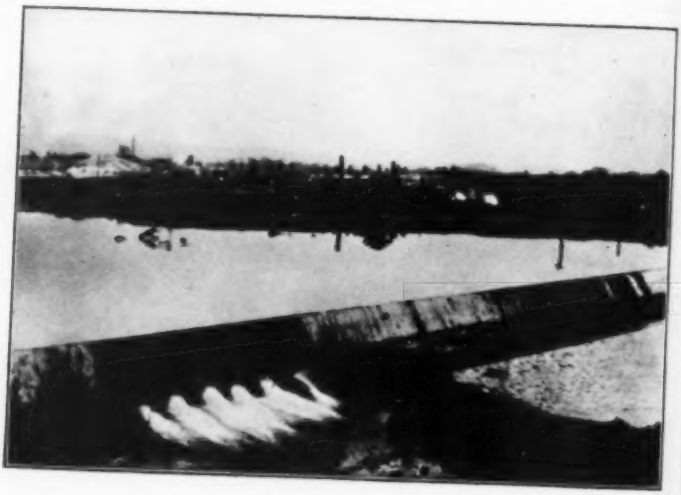


FIG. 10.

mound was, therefore, covered with a reinforced concrete cover; the cover being designed by the use of suitable steel frames to be entirely self-supporting, and, in fact, to form a species of inverted cup placed over the earthen mound but not in contact with it. Numerous pipes were inserted in this concrete cap and the gas coming therefrom was led away and burnt at flares at a safe distance. Fig. 9 shows the mound covered with concrete and the arrangement of gas pipes on it. The well in this condition produced without misadventure until December, 1918.

Suitable arrangements were made by drains and pipe-lines to collect all the oil produced from the seepages in a central sump, to which was also led the oil being drawn off from the mound. A number of seepages were actually in the bed of the Buena Vista River, amounting to some considerable number of barrels daily, and this oil coming to the surface had to be specially dealt with, both in order to save it and to prevent the constant pollution of the river throughout its length. To accomplish this a concrete dam was built across the river, as shown in Fig. 10, and the water level so adjusted by means of valves that the accumulating oil on the surface of the river would automatically be drawn off through a long rectangular orifice, some 20 ft. in length, on the inner side of the dam near to the left bank. The orifice was connected to a compartment arranged inside the concrete dam, and from this compartment a pipe-line led the recovered oil to the central collecting sump.

The arrangements having been completed, the period of activity connected with the well up to the time of extinguishing the fire was succeeded by a period of comparative calm from March, 1915, to December, 1918, when nothing outwardly was to be noticed at Potrero except the concrete mound, the gas flares and the pumps pumping away to storage the automatically gathered oil.

The late Mr. T. H. Vaughan, Member of this Institution, was in charge of all the operations connected with putting out the fire and leaving the well in a producing condition.

On the night of December 4th, 1918, the gauger of the storage tanks noticed that the tank then being filled from the well contained a thickish brown looking liquid instead of the usual black crude oil. A sample was taken and examined, and was found to be an emulsion of oil and salt water. Tests proved that no water would settle out within practicable limits of heating, that the water could not be separated by the action of the centrifuge and that the emulsion would not burn.

Fortunately, at this time, there was some spare earthen storage, into which the emulsion was pumped. As it could not be foretold how long it would take to close in the well, immediate steps were

taken for the construction of additional earthen storage of some three million barrels' capacity. As the well was giving some 40,000 barrels of emulsion daily, it was thought that this sized reservoir would take care of the production of emulsion until the well was closed in.

It is of interest to record here that the emulsion going into the storage tanks from the flow-line was a very viscous coffee-coloured liquid of about 0·979 specific gravity, which, on analysis, was found to contain some 54 per cent. of salt water; it was noticed that the emulsion coming from the leaks at the well head was a darker colour and that, on standing, some salt water settled out. It appeared, therefore, that the emulsion changed its character due to its passage through the 800 metres of flow-line and the valves on it. To test this a small hole was drilled on the flow-line near the well head, a sample of emulsion was taken, and on examination settled out almost immediately some 36 per cent. of salt water, whereas, as already stated, the emulsion going into the storage tanks would not settle at all.

It was observed that the seepages one by one stopped producing, and that the gas burning at the flares diminished considerably.

It was thought that two methods of closing in the well should have a fair chance of success. One method was to cut away the concrete cap and remove as much of the mound as was necessary to enable one to get at the well head, as it was considered that with the diminished amount of gas being given off, one might be able to shut off the leakages and shut the valve on the well head. The other method which it was thought might be worth trying again was that of the tunnel scheme which had been previously abandoned owing to the amount of gas and oil encountered in sinking the shaft. Both these schemes were proceeded with without delay. A great deal of the concrete cap and of the mound were removed, when the gas exuding from the earthen mound caught fire, apparently spontaneously. While this gas was considerably diminished in quantity from what it had been when the well was producing crude oil, the flames were still sufficient to prevent the labourers carrying on the work; and although it would doubtless have been possible to extinguish the gas, it would have taken some considerable time to make arrangements to do so, and there would have always been the probability of further spontaneous ignition. This scheme, therefore, had to be abandoned.

The tunnel scheme meanwhile was being proceeded with, and the shaft had been sunk to a depth of 200 feet, and the tunnel driven in towards the well. When the tunnel was about four feet from the well, a considerable amount of oil, water and gas broke in from around the well, driving out the tunnellers, partially filling the

shaft and making the continuance of the work practically impossible. The conditions of work during the driving of the tunnel were extremely unpleasant, oil and water oozing from the walls of the tunnel in every direction, whilst the heat and amount of gas present added to the discomfort of the workers. It was, therefore, a great disappointment that the scheme had to be abandoned, after the work done in overcoming all the difficulties of getting so near the well with the tunnel. As both the proposed methods had proved useless, it was decided to again attempt to drill into the well through the slanting hole drilled when endeavouring to put out the original fire in 1915, with this difference, that in the present case it was decided to use instead of the 8-in. rose bit, a 4-in. annular milling cutter so arranged that when the 8-in. casing had been entered it would be possible to pump through the cutter into the well some semi-solid material which, while fluid enough to be pumped, yet would be solid enough to close up all the leaks at the well head. Fig. 11 shows how this milling cutter was arranged and the method taken to guide it centrally into the well. The drilling in was accomplished satisfactorily, and it only remained to connect up the drill stem to the pumps and pump in the semi-solid material, when it was hoped the well would be shut in. Considerable thought had been given to the question of the best material to pump into the well, and it was finally decided that, to begin with, Indian corn should be pumped in. It was thought that this material, mixed with water, while small enough to be pumped into the well without difficulty, was yet large enough not to find its way out through the different leaks, and would also pack up tightly, by the pressure of the outflowing emulsion, to entirely shut off the leaks. A ring of 8-in. pipe was arranged with suitable valves and connected to the discharge of one of the main pipe-line pumps, whose suction was connected to a water tank. On the opposite side of the ring to the connexion to the pump a pipe was led to the drill stem of the milling cutter. The arrangement enabled either half of the ring to be pumped through at will, and by suitably placed tees and funnels, one half of the ring of pipe could be filled with corn, and whilst this was being pumped to the well, the other half of the ring could be similarly filled. Almost immediately the main line pumps were started and the first pipe length of corn and water delivered to the well, the flames began to appreciably diminish, and after less than ten minutes' pumping the well had ceased to produce either gas or emulsion. After the leakages had entirely stopped, some cement grout was pumped into the well, and in order to stop the small leakage round the drill stem, where it entered the casing, a little jute, cut into pieces 3 in. or 4 in. long, was added to the cement.

This effectively stopped the last remaining leak and finally shut in the well, to the great relief of those in charge who had to deal with the serious problem of disposing of the enormous quantity of emulsion being produced from which, at that time, one neither knew how to extract the crude nor even to burn it in its emulsified condition.

The late Mr. J. S. Smith, Member of the Council of the Institution, was intimately connected with all operations on this well from the time of oil being struck until it was closed in, and it was largely due to his mechanical genius that the numerous difficulties encountered were successfully overcome.

For permission to present the paper the author is indebted to Mr. J. B. Body, Director of the Mexican Eagle Oil Co., under whose general direction in Mexico all the operations of the Company were conducted throughout the period dealt with.

DISCUSSION.

The President, in opening the discussion, said the members had had the privilege of listening to a most interesting paper, and the very fine lantern slides which had been shown gave a faint idea of the appalling conditions under which the many difficulties that were encountered were overcome. It was really extraordinary that it was possible to get men to work under the terrible conditions that had been illustrated, and as an example of pluck and perseverance he thought it would be very hard to beat. The fear that the rods securing the bell nipple would melt away was, he thought, more than justified, in fact it seemed to him an extraordinary circumstance that that did not prove to be the case. He had seen the results of many oil fires on board ship, in several of which cast-iron had been melted like tallow. Evidently the accumulation of coke round the rods, to which the author had referred, must have taken place almost immediately, otherwise the rods, which were only 2½ inches in diameter, would have been burned through in a very short space of time. The well itself seemed to have been somewhat unfortunate. After all the heroic methods that had been adopted and the great amount of work expended on it, it lasted only four years, and much difficulty was experienced in plugging it at the finish. He thought the methods adopted showed great ingenuity, and it was an extraordinary fact to him that the engineers managed to hit the pipe and drill it as well as they did, considering the distance from which the operations were carried on. If the work had been very much off the centre the greatest difficulty would have been experienced in getting the rose bit to bite into the tube.

VIEW OF FIRE AND CONSTRUCTION OF EARTH BANK.

VIEW OF EARTH MOUND SHOWING GAS BURNING.

VIEW OF EARTH MOUND AFTER ALL FIRE WAS EXTINGUISHED.

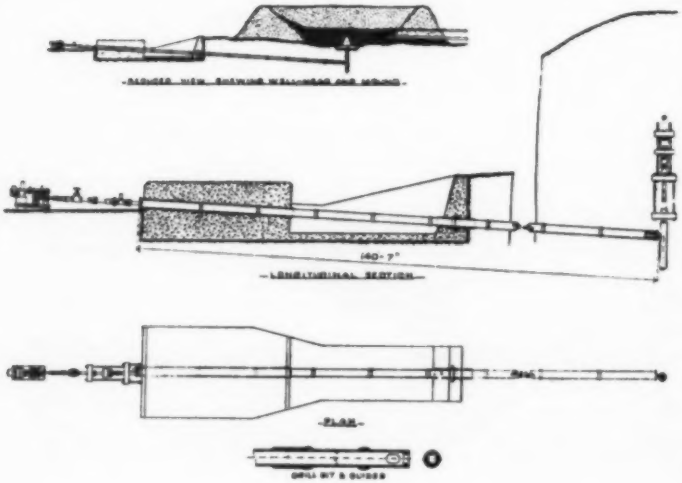


FIG. 11.

He concluded from the author's statement that the well was finally sealed and that nothing had been done with it since. A very large quantity of the emulsion, to which the author referred, must have been collected, and he would like to know whether any use was made of it either at the time or subsequently.

There were probably many gentlemen present who knew Mexico, and some of them might have encountered difficulties of a similar nature to those described in the paper, either in that or in other countries, and he was sure the members would be delighted to hear their experiences.

Mr. A. Frank Dabell said it was the duty of the members to seek to determine what lessons were to be learned from the experience gained in connexion with the well to which the paper referred.

One of the most important points that should emerge from the paper was the location and the weight of the casing used. It appeared to him from the section that had been shown, and the description which had been given, that in the Potrero No. 4 well 8-inch casing was standing in the well with nothing to support it. He desired to ask the author if that casing subsequently moved, because it was a wonderful occurrence that 1800 feet of casing should stand on a small annulus of lime shell or lime rock without movement, as it was to be expected that, after millions of barrels of liquid had passed through the lime rock, the ledge upon which the casing was resting would be worn away by attrition, so that the casing would slide down. If it had slipped down by reason of the attrition of the liquid, some conclusion might be arrived at governing the emulsion given off by the well afterwards. If the casing was still in the same position, he presumed the emulsion was simply due to the intrusion of water.

The next point of interest was the fact that in the emulsion given off at a distance of 800 metres from the well no water settled out, whilst at the well itself 36 per cent. of salt water settled out. He concluded from that circumstance that the agitation occurring in the 800 metres of pipe caused a more thorough emulsion than in the well itself. So far as he knew the fact of settling out 36 per cent. of water at the well mouth would produce no benefit, because he was not acquainted with any method of dealing commercially with an emulsion which had reached that stage.

For the benefit of those who proposed to use a bell nipple or similar form of nipple in the future (and, personally, he was not acquainted with any better form than the bell nipple itself), he suggested that it should have four branches, so that in the event of a fire occurring in the earthen reservoirs to which the oil was being led it would be possible to close off that particular outlet and

use the others without having to close the well in itself. Closing a well in had, in many cases, led to the tearing off of the fountain connexions. He further thought that those who wished to study that subject should read the present paper in conjunction with a paper recently read by Colonel Hickling at the Institution of Mining and Metallurgy. In that case an entirely different procedure was adopted. The oil was not allowed to develop its pressure at the surface; it was retained in the oil-sand or in the reservoir itself; and engineers had to choose between those two systems when opening up fields with great pressures.

He thought it should be mentioned, in connexion with the lessons to be learned from the Mexican well under discussion, that the conditions were unique in that country; they differed entirely from those in Russia, Rumania, or Trinidad, inasmuch as no detritus was thrown from the well. It was a perfectly clean well, and it was not necessary to deal with the huge volume of sand which caused collapse and destruction of casing.

Mr. Gordon Pitt said that the paper brought before the members very vividly the kind of problems which the practical oil man had to solve under conditions of extreme difficulty with very little in the way of appliances ready to hand; and it also brought to the notice of those who had no personal experience of the subject a new sidelight on some of the problems of oil production. He thought there had hardly ever been in the history of the oil industry a more interesting and at the same time difficult problem than the one presented by the well described by the author when it was first brought in, and later when it took fire, partly because at the time it was brought in it was easily the world's record well, and equally when the fire took place its dimensions were of an extraordinary nature. As one who had had practical experience both of the controlling or capping of large producing wells and, unfortunately, of oil wells on fire, it had been a matter of exceptional interest to him to hear the author's detailed history of how such an extremely difficult piece of work was eventually carried out with great success. There were one or two questions he desired to ask. In the first place, the earlier slides that were shown in illustration of the paper did not contain any sign of a derrick. He could not help wondering what became of the derrick. No superstructure seemed to exist at the time the bell nipple was placed *in situ*. He had also been much interested in the section of the well, which appeared to indicate that the 8-inch casing existed for 1850 feet and did not go lower, while the oil was found at 1911 feet. Was it the case that the remaining 60 feet of the hole remained uncased all the way through? He noticed also that the temperature of the crude oil was 147° F., and he would like to ask if that was a usual figure.

He further wished to ask whether the oil produced from the well was entirely free from sand. If that was not the case it seemed almost incredible that the steel and iron work used in the nipple should have lasted for the period they did, in view of the amount of oil passing through. He further desired to enquire whether the foam preparations used in connexion with the fire in 1914 were in any way similar to those which it was customary to use at the present time. The fire occurred comparatively early in the history of very large producers, and although that was not so many years ago, considerable experience had been gained in connexion with foam preparations since the time of the occurrences narrated in the paper. Finally, he wished to mention that, although at the time the particular incident to which he was about to refer occurred he had heard nothing of the details of the manner in which Potrero No. 4 well had been closed in, when faced with conditions which were likely to give rise to similar difficulties in Trinidad a year or so afterwards, the way was prepared beforehand for occurrences of that nature by using a tee-piece with two control valves, one on the upright and one on the branch, as a permanent fixture to the 8-inch string of casing. The President had already expressed his amazement that the steel and iron work stood up to the heat of the fire. Personally, he thought it was an extraordinary thing that it did so because, in the case of one fire of which he had experience in which the well was producing something like 3000 barrels an hour and which was burning freely for about 24 hours, there was no doubt that the occurrence which eventually enabled the engineers to get the fire under control was that some twelve feet of 8-inch drill pipe which was standing up in the rig eventually, under the effects of the heat, bent right over and, practically speaking, sealed the well.

Sir Frederick W. Black said he was not quite sure from his hasty reading of the paper whether the great flow of oil down the river valley, which was described on page 143, was on fire at the time it was flowing, or whether it was fired at some point lower down the river. He hoped the author would deal with that point in his reply. The only other remarks he wished to make were of an extremely general nature. He had the pleasure of meeting Lord Cowdray officially about the time the Potrero well was in very active operation, about 1912–13, and he gathered from such general information as Lord Cowdray then gave him what a wonderful piece of enterprise his entry into the Mexican oilfield had proved. He thought it was only right to say that at that time, much as the Britisher had done in the Near East and the Far East, the Potrero No. 4 well was the first great piece of British oil enterprise on the other side of the Atlantic. Side by side with the extremely

interesting paper which had been given that evening he urged those members who had not already done so to read the paper which Mr. Doheny, of the Mexican Oil Company, gave at the American Oil Convention at Chicago in 1922. Mr. Doheny went down from California to Mexico City; and as he saw the fine tropical vegetation and felt the teeming heat coming up from the soil, he wondered what the prospects were of finding oil in such regions. Mr. Doheny went on to tell of the extraordinary success which he eventually met with in places where others had failed. Not less remarkable than the finding and the producing of the oil was the story he told of how to find a market for it. That lay, perhaps, a little outside the province of the present meeting, but, nevertheless, it was in itself a story of extraordinary interest. Probably many of the pioneer companies in that field had to consider the same problem; *viz.*, with such enormous volumes of oil coming upon the market so suddenly, how could uses be developed for its employment instead of allowing it to be burned or run to waste down the river valleys. From the personal point of view he desired to emphasise the very pleasant reference that had been made by the author to their old colleague, the late Mr. J. S. Smith, and also to the late Mr. T. H. Vaughan and Lord Cowdray. He thought such things should be mentioned because at the present day this country prided itself that British influence in the oil world was fairly considerable, but he did not think until quite recently it had been fully realised what it amounted to.

Mr. Charles Dabell said that one outstanding feature of the well the author had described was that in its initial stage it had not been capped. The point he wished to emphasise was that, in his opinion, wells should be allowed to flow for some period to their full extent, though there be considerable trouble in dealing with the production.

Mr. Alexander MacDougall asked whether, when the earth mounds were brought sufficiently close to the burning mass of oil and gas, would it not have been possible to drag a very large and heavy casting over the casing or spring area, and thus by its weight extinguishing the fire at its source?

Mr. E. A. Evans asked whether any toxic effects were produced on the men by the large amount of gas which was produced. He would also like to know what methods were adopted to counteract the skin affections that were produced on the men by that gas, especially the irritating sores which were produced on the eyelids to which the author had referred. Such questions arose very often in connexion with industrial problems, and it would be of interest to know what was done for the workpeople on the spot who were suffering from those troubles.

Dr. J. A. Leo Henderson desired to ask how the author managed to orientate the drill stem upon the particular point that he wished to perforate in the casing column, and how many revolutions were used in drilling through the steel. With regard to the pressure of the well, he would also like to ask if a pressure test was taken when the well was ultimately closed in, and, if so, what was the record.

Mr. E. Lawson Lomax said that one of the previous speakers had asked a question with regard to the effect of the gas upon the eyes. He was able to state that the effects produced were a type of conjunctivitis. They might be avoided, to a great extent, if the men who worked in the gases were prevented from rubbing or touching their eyes in any way. The trouble could be much alleviated by the use of a boracic acid solution, and the eyes could be further protected by painting the eyelids with castor oil. A great amount of relief was also obtained by the use of a cocaine solution in the eyes.

Mr. A. E. Chambers, in reply to the President's questions, said that he believed no commercial method had yet been found for using the emulsion. The well was finally closed in by pumping in Indian corn and cement as described, and, as far as he was aware, nothing had since been done to it. In reply to Mr. A. F. Dabell's question, the column of 8-inch casing was not supported from the top, but did not apparently sink at all throughout the long period that the well produced; without doubt the 700 feet of blue marl through which it passed assisted in keeping it from moving. Mr. Dabell questioned the benefit to be derived from settling out 36 per cent. of water from the emulsion. The benefit was that in settling out 36 per cent. of salt water it was necessary to find that amount less space in storage, which was a considerable advantage. The author quite agreed with Mr. Dabell with regard to the benefit of having branches on the tee of the bell nipple device. Colonel Hinkling's paper, to which Mr. Dabell referred, dealt only with wells producing oil containing a large amount of sand, and described a method of dealing with such wells.

In Mexico modern methods of drilling-in a well were such that the well was never out of control. Production could be taken out at any rate it was required, and, as a rule, the wells were always producing with considerable pressure on them. Incidentally, he desired to suggest that perhaps some member of the Institution might, in the future, care to write a paper on modern methods of bringing in Mexican oil wells.

Referring to Mr. Gordon Pitt's remarks, the author said that with regard to the derrick, part of it was blown away when the well

came in, and the rest was taken down in order to make the space clear for putting up the controlling device. The temperature of the crude oil was as usually found in that part of Mexico. The oil was nearly the same temperature in all the wells in the southern fields, and it was entirely free from any sand. In reply to the question as to the foam material used, the materials used to make the foam were in all essentials the same materials as were used at present for making foam mixtures. In reply to Sir Frederick Black's question regarding the oil burnt on the river, that oil was deliberately set on fire in order that it might be got rid of, and so that it should not pollute the whole extent of the river. The fire was confined to a district a number of kilometres away from the well, and in such a manner that there was no possibility of the fire going backwards and reaching the well.

As to the effects of the gas on the workers, they produced unconsciousness and, unless the worker was quickly removed to fresh air, death, presumably from suffocation. Happily, in connexion with the Potrero No. 4 well there were only two fatal casualties in dealing with the fire, due to the two men slipping and getting burnt. Mr. Lomax had already answered the question asked with regard to the treatment that should be adopted for combating the effect of the gas on the eyes. In all cases at Potrero a medical man was present, and the author was unaware of the details of the prescriptions that were used, but he believed they were mainly cocaine and boracic acid. Some of the drilling men seemed to obtain considerable relief by applying a slice of raw potato upon each eyelid.

Dr. J. A. L. Henderson had enquired how it was the engineers were able to hit the well so accurately when drilling into the casing. The reason was that the first day the well caught fire the centre of the well could be seen, so that a surveyor was able to locate the centre line accurately. Its position was definitely established in relation to three or four fixed points, so that there was never any difficulty afterwards in getting its direction, although it was impossible to see it after the fire was well established. The laying out of the concrete blocks and the 18-inch guides was carefully done with surveying instruments in order to get to the centre of the well, and, as he had already stated, when the well was finally encountered the centre line of the 18-inch guide was only about 4 inches to one side of the centre of the well. That was ascertained by running in impression blocks; from these it was possible to get the exact distance of the centre of the well casing from the centre of the 18-inch guide casing. A 6-inch guide pipe was then inserted inside the 18-inch guide pipe up to the well casing, and by suitably designed distance pieces was kept in such a position inside the 18-inch pipe that its centre line coincided with the centre line of the well. The

4-inch drill stem and milling cutter was then used inside this 6-inch pipe, and by it kept in position. The cutter was revolved at about 20 revolutions per minute. A test taken some days after closing in the well showed no pressure; presumably this was due to the cement having set and securely plugged the well.

In reply to Mr. MacDougall's question, the author said such schemes were considered, but were not deemed practicable owing to the immense size that such appliances would have been. A reference to Fig. 6 will give an idea of the dimensions that would have been required.

A vote of thanks was carried with acclamation, and the meeting terminated.

Mr. Robert Stirling subsequently wrote that he has been more than interested in reading the history of "Potrero No. 4," given with so much useful technical detail by Mr. A. E. Chambers, as although he was intimately associated with the history of the early stages, he has not been in a position to follow consecutively the details of the later happenings.

Many useful hints can be gleaned from a careful study of the history of "No. 4," which clearly holds the record for having produced the largest quantity of marketed oil during its troubled lifetime. Its volume of free flow had been without doubt surpassed by several wells in Baku, but such wells there flowed for a maximum of six weeks before becoming plugged with sand and generally destroyed. Control was impossible owing to the large diameter of the wells, and the use of "store-pipe" casing.

The hard strata in which the oil was found, and the absence of loose sand with the oil in "No. 4," facilitated all the operations of control, excepting the final plugging. The strata were not disturbed by the free flow of the oil, and the flow was completely stopped without the risk of the well becoming plugged by sand. The well had been drilled to the cap rock some six months previously, and new heavy casing used, which had become firmly gripped and held by the characteristic swelling of the marls through which it passed; otherwise it might have been impossible to control it. Experiments in Baku and recent experience in Trinidad give a production of 2000 barrels per day as the most which can safely be obtained from loose sands without undue disturbance of the strata; whereas 30,000 barrels per day could be taken from "No. 4."

The unrestricted flow of wells tapping loose oil sands, under high gas pressure, invariably results in serious damage, and is generally fatal. It should be an axiom that such wells should never be allowed uncontrolled flow, but at the same time the flow

must be maintained, and never entirely stopped, or they will almost certainly become plugged by the loose sand in the casing. In the case of control being lost, there is no reason why it cannot be regained by methods similar to those described, only varied to meet the conditions, and the well saved, provided it can be done before the casing or strata become irretrievably damaged. This is the essential difference. There is no time to improvise, as every moment of uncontrolled flow is dangerous. Carefully thought out plans, based on experience of the conditions encountered in the particular oilfield, must be made, and appliances provided beforehand, primarily to prevent loss of control, or if lost by accident to regain it as speedily as possible.

As regards the capping device escaping damage by the subsequent fire, it is rather curious to contemplate that the lower part of the centre of an extensive oil fire may be comparatively cool, because the air is prevented from reaching it by the smoke and vapours from the burning oil. A hollow cast-iron column was found standing in the centre of a burnt-out oil tank, covered with carbon and soot, and showing no signs of intense heat, although the sides of the tank had been collapsed by the heat.

The spread of the fire up stream was prevented by a very simple method, evolved from observations made in Baku. There, during a conflagration, streams of oil from flowing wells could be seen running in open channels into burning reservoirs, and yet the fire did not spread to the wells. In the method adopted the oil was directed into channels by rough weirs constructed across the stream to obtain a fairly rapid current, which was invariably effective. As an oil fire burns only on the surface, and spreads by heating the adjacent oil surface to the flash point, the stream of cool oil is sufficient to prevent the fire spreading up the channel.

The difficulties encountered in dealing with the leakages and extinguishing the fires seem to have been greater than those met in controlling the well, and to have been very considerably added to by the application of concrete for the protection of the controlling device. It prevented proper access to the controlling device for the purpose of keeping it in repair, and also the dealing efficiently with the leakages when they started. This, it was foreseen, would probably be the case, and was clearly pointed out when the idea was suggested at a very early stage of the history of the well.

Many of the methods devised to meet the troubles which arose were most ingenious, and the record of them cannot fail to be of considerable future value.

INSTITUTION OF PETROLEUM TECHNOLOGISTS.

Annual Dinner.

The Fifth Annual Dinner of the Institution of Petroleum Technologists was held at the Connaught Rooms, Great Queen Street, on Tuesday evening, April 17th, 1923, the President, Mr. H. Barringer, occupying the Chair.

The guests of the Institution were :—Mr. R. Gilman Brown (President, Institution of Mining and Metallurgy), Engineer Vice-Admiral R. B. Dixon, C.B. (Engineer-in-Chief of the Navy), Mr. James Hamilton (Vice-Chairman, Anglo-American Oil Company), Mr. W. St. D. Jenkins, C.B., C.B.E. (Director of Navy Contracts), Mr. G. K. Menzies (Secretary, Royal Society of Arts), Sir Oswyn A. R. Murray, K.C.B. (Permanent Secretary to the Admiralty), Mr. J. W. L. Oliver, C.B.E. (Director of Naval Stores), Mr. T. Outen (Honorary Solicitor), Mr. Francis E. Powell (Chairman, Anglo-American Oil Company), Sir Archibald C. Ross, K.B.E. (President, North-East Coast Institution of Engineers and Shipbuilders), Air Vice-Marshal Sir Geoffrey Salmond, K.C.M.G., C.B., D.S.O. (Air Member for Supply and Research), Mr. David J. Smith (President, Institution of Automobile Engineers), Mr. W. C. Sneath (Honorary Auditor), and Mr. Philip C. Tennant (Chairman, Petroleum Section, London Chamber of Commerce).

"The King."

The toast of "The King," which was proposed by the President, was enthusiastically received, and accorded musical honours.

"The Services."

Sir Frederick W. Black, K.C.B. (Past President), in proposing the toast of "The Services," said : Mr. President and Gentlemen, I have done my best in connection with the last two or three Annual Dinners to persuade the President to let me off inflicting myself upon you, because I feel that a great and growing Institution like this is entitled at each Annual Dinner to have the fresh thoughts of a fresh mind.

I want to-night to say a little about the relationship between the Services and the Technologists. I think in our four previous dinners this Institution has received the toast of "The Forces" as loyally and cordially as any other representative gathering of Britishers. The subject of what was done in the War is by no means exhausted, but there are occasions when one may perhaps turn aside from it to look at things more in the light of present-day

problems. Our friend, the Secretary of the Admiralty, as well as the naval officers who are here this evening, are familiar with a phrase that is used in the Naval Discipline Act, namely, that "The welfare of these Dominions depends, under the good providence of God, upon the Navy." I quote that phrase for a double purpose. First of all, because it is something nice to say about the Navy, although it has been said a great many times before. In the second place I think if any member of the Institution of Petroleum Technologists wished to swell his chest with pride, he might parody that fine expression, if it would not be irreverent, and say that "Under the good providence of God, the mobility of the Navy, of the Army, and of the Air Forces, depends, in the last resort, upon the individual Petroleum Technologist." (Laughter.) I think that, after all, it would be a fairly pardonable pride, always assuming that he was really doing his best in every way, either to increase the available quantity of oil, or to give the Government the quality demanded by their terrific specifications. (Laughter.) I remember a gentleman who was attending a dinner of people interested in the metal trade who got up and said: "We read these terrible Government specifications; impossible tests are set out in them; we meditate and say: 'The thing is impossible.'" (Laughter.) "Then," he said, "We stand up and we carry them out." (Laughter.) I am not sure that that is not something of what the petroleum technologists think and do, in regard to the requirements of the Government, always, of course, within the limits of scientific and technical possibility and of what the crude material will produce. I think there is another way also in which one may look at the relations between the technologists and the Services. I suggest to you that there is a very great affinity between the professional work of the petroleum technologists and the professional work of the Navy, the Army and the Air Force, in this respect in particular, that in all there is a great deal of pioneer work, and a great deal of work which is done a long way from the newspaper man and his notebook. It is done somewhere out on the rim of civilisation. We can follow the geologist and engineer through the world from Papua, to his life with the wild men of Borneo; or away in Burma, Persia, the Caucasus, the Carpathians, or the Balkans, and so on until we get to the shale-fields of Scotland. Then we should have to follow him to the Mackenzie River, in the north of Canada, to Patagonia, the Argentine, Venezuela, and the great oil fields of the United States of America. If you compare the work that is done by petroleum men under such conditions, I am sure the Navy, the Army and the Air Force would admit that the environment and the character of the pioneer work of the petroleum technologist are somewhere on the

same plane, except for the actual fighting, as that of the fighting forces of the Empire. One body of technical men can fully appreciate the difficulties of another body. We all realise something of the problems that have to be met in the Admiralty, the War Office, and the Air Ministry in maintaining an efficient state of preparedness in times of stress in regard to finance, and in times when many generous-minded men are believing that the millennium has come, and that the League of Nations is going to abolish war. However we may sympathise with those views, we feel that history is for a moment a little bit the other side, and our faith in human nature is not at present quite up to that level. Therefore we sympathise with the authorities that have to face these problems.

It is a very great pleasure to me to couple with this toast the name of Admiral Dixon, the Engineer-in-Chief of the Navy. I have known three of his predecessors, beginning with Sir John Durston, going on to Sir Henry Oram, and then on to Sir George Goodwin, and I think, if a non-professional, non-technical man may say so, there are few departments in which all-round training and efficiency stand out as they do in the Engineering Department of the Royal Navy. I believe that to be due largely to the fact that the young engineering officer, after his theoretical training and his college course, goes to sea; he rises in his profession; then he comes back to the Admiralty; then he is sent away again to sea, or to supervise the building or repair of engines; and he may come back again to the Admiralty for the purpose of utilising the knowledge thus gained in the checking of designs. I think there are few men who receive such an all-round training on every side of their work as the naval engineers. Perhaps it is because of that, and because of the fact that they are men of the world, that they possess that very fine sense, which is always found in the engineering department, of co-operation with other people. I remember, when I was a junior head of a department in the Admiralty, that Sir John Durston, who was a very experienced senior, told me how he managed to keep on good terms with other people. He said to me: "When one of my officers come to me with a problem that concerns other people, with regard to which I do not know whether or not we shall have a difference of opinion, I call them together and talk it over and try to come to some friendly agreement about it," and I am sure that Admiral Dixon follows that tradition in carrying on his work.

Now, I want to say a word about their responsibilities. Those of you who are engineers will not require me to say much on that point, but I think there are two or three things which I might say. I read, about eighteen months ago, some statements by members of the Government that in the pre-War Navy 45 per cent. of the

ships were oil-burning, but that a year or two after the war the figure was practically approaching 90 per cent. Men like Admiral Dixon have seen that development take place. It is a development of twenty years only, so that they have seen it right through. I have not the slightest doubt that the day is coming when the Navy will be 100 per cent. oil-burning, but they will not see it through to the end, because the Navy will be 100 per cent. oil-burning till the distant time comes when it may have to get its energy from other sources. I think I am not far out in saying that if you pick up a pre-War Navy List you will find that the highest indicated horse-power of any ship of war was then somewhere in the neighbourhood of 75,000 or 80,000. Quite early in the war we had one or two ships in which the indicated horse-power had already gone up to 112,000. Soon after the war ended, a ship, in which the indicated horse-power was in the neighbourhood of 145,000, ran her trials; that is to say, in the course of some seven years or so, the maximum horse-power of some types of ships in the Navy was double the pre-War maximum. Not only have the number of oil-burning ships at sea doubled themselves, but the horse-power has also doubled. I believe I am right in saying that the horse-power of the biggest Cunarder is not very much more than 70,000, so that the figures I have quoted will give you an idea of the immense responsibility that devolves upon a department such as that over which Admiral Dixon presides.

I now want to give you one or two instances of the fine spirit of co-operation that has prevailed in the Services. I will give you one from the Army and one from the Air Force. On my first day, I think, at the Ministry of Munitions in 1915, I received a visit from General Bingham, of the War Office, a man whose services in the organisation of munitions were, I venture to say, beyond praise. He remarked that as between the War Office and the Ministry of Munitions there was never going to be any division, and said: "I am going to do my part to take care of that"; as far as it lay in human power, we did take care of it. The other instance I want to refer to is this. We have present with us to-night Air Vice-Marshal Sir Geoffrey Salmond. When I went out to India with three engineers in 1917 to examine the munition factories, the thought occurred to me that perhaps we could do something *en route* to help the Air Service in Egypt with some of their supplies, and I have the very pleasantest recollections of the cordial way in which we were received by General Salmond's officers at Port Said. On our homeward journey General Salmond attached one of his officers to us to accompany us back to England, so that we might represent with double force some of his requirements. As an instance of what underlies that fine spirit of co-

operation of which I have spoken, I should like to mention this: Many of you have no doubt read Mr. Winston Churchill's book on the "Great Crisis," and I want more particularly to draw your attention to what he said about Admiral Sir Arthur Wilson. There were a good many of us in the Admiralty during the war who used to see that quiet figure walking about at any hour of the day and night, and I do not think many of us could have said what his exact official position was. We might guess that he had something to do with the War Staff, but what we did know with certainty was that he was putting his fine strategic brain and immense experience to the uttermost at the service of his country. Mr. Churchill said: "He was the most selfless man that I ever met or read of." I do not think one can pay another a finer compliment than that. If, for the present purpose, I were to divide the world into five great classes—sailors, soldiers, airmen, civilians, and petroleum technologists—I think we should all have to confess that we fall very short of him in carrying out our ideals of duty. We are told that Sir Arthur Wilson never thought of duty as a thing that ought to be done for reward; it was simply "our job" that just had to be done; and as our friend, Mr. Powell, would say in one of his expressive Americanisms: "That's all there is to it." It is because the Services were always striving towards it, although we have not reached that ideal, that the country got through its war problems. It is because of that endeavour by us all that we shall surmount those obstacles of peace time, which are no less difficult than those of war.

Gentlemen, I should like to have proposed this toast to you in more eloquent language, but I know it goes home to the hearts of all of you, however poorly it may be conveyed to you by the speaker. I give you the toast of "The Services"—the Navy, the Army, the Air Force, and the Reserve Forces, coupled with the name of Vice-Admiral R. B. Dixon, Engineer-in-Chief of the Navy. (Cheers.)

The toast was heartily acknowledged.

Engineer Vice-Admiral R. B. Dixon, C.B. (Engineer-in-Chief of the Navy), in responding, said: Mr. President and Gentlemen, it is not an easy task to reply to this toast because at the present time the Services are under a cloud—a financial cloud. Of necessity they have been much reduced, and a large number of officers and men have been placed, through no fault of their own, on the retired list. I believe there are a few people who consider that a Navy is an expensive and an unnecessary luxury, but undoubtedly the majority agree that so long as there is a British Empire there must be an efficient British Navy. (Cheers.) The Army and the Air Force have also been largely reduced, and in view of these reductions it is all the more necessary that the Services should be kept in the

highest state of efficiency. (Hear, hear.) As regards the personnel I think the traditions of the Services will ensure that the officers and men will keep themselves efficient so far as possible. The question of material is another matter that has to be considered. It is undoubtedly essential that we should have research and experiment. The three Services, as Sir Frederick Black said, are very much alike in one way—they all require to use petroleum. Neither the Navy, nor the Army, nor the Air Force can move without petroleum, and therefore the activities of this Institution are of the utmost value to us. The Navy is chiefly interested in the heavier oils, the Army and the Air Force in the lighter oils. We in the Navy are also to some extent interested in the lighter oils, and, as Sir Frederick Black has said, petroleum technologists can assist us in that respect to a very large extent. We should like to see them give us a standardisation of some of the lighter oils, say kerosene, on somewhat similar lines to the proposed standardisation of petrol, so that we could be sure that the engines which we design to-day to run with kerosene will run satisfactorily with the fuel of to-morrow. I was reading last year an account of a dinner at a sister institution, and the Press were very angry because members of the Services occupied so much time with their speeches that other speakers who were worth hearing were more or less crowded out. (Laughter.) I am not anxious to incur the displeasure of the Press in this respect (laughter), and I will, therefore, conclude my remarks by thanking you on behalf of the Services for the cordial manner in which this toast has been received. (Cheers.)

"The Petroleum Industry."

Sir Oswyn A. R. Murray, K.C.B. (Permanent Secretary to the Admiralty), in proposing the toast of "The Petroleum Industry," said: Mr. President and Gentlemen, I appreciate very highly the honour of being asked to propose this toast, although I am painfully conscious that I have very few qualifications for dealing with so large and technical a subject. I confess that when I accepted your invitation to come to this dinner nothing was further from my mind than that, having dined, I should be called upon to play any other part than that of a pleased, interested, and replete observer. But even at the price of having to display my ignorance in a speech, this is for me a great and interesting occasion—to be present at this gathering of the Institution of Petroleum Technologists, and to see around me some of the men who, during the last thirty years, have probed so deep into one of the most valuable and recondite secrets of nature, and on the basis of their researches have built up an industry as great, as highly organised, and as indispensable as any in the world to-day. I daresay it has occurred to others

besides myself that in a large gathering of those interested in any industry or profession there is apt to be radiated a definite sort of impression—what the Society of Psychical Research would call an *aura*—which is perceptible to the careful observer. For instance, a gathering of lawyers always has a special atmosphere peculiar to itself, which I cannot describe otherwise than saying that it is exactly the sort of atmosphere one would expect in a gathering of the privileged parasites of civilisation. (Laughter.) I daresay that a gathering of Civil Servants would have a special *aura* of its own, imperceptible to me, but betraying to other people the unsocial instincts of the bureaucratic bullies of society. (Laughter.) I can assure you that the *aura* of this gathering is one that arouses in me the most elevated and pleasing impressions. Not for nothing was it that the psalmist of old took as the symbol of co-operation and harmony the precious oil that flowed down Aaron's beard, a very primitive form of pipe-line. (Laughter.) I take it that I stand here to-night in a more or less representative capacity, because of my association with the Board of Admiralty, whose interests in the petroleum industry, and whose gratitude to you, to whom the progress of the industry is so greatly due, have existed in an ever increasing degree for so many years. But in spite of that I should like to indulge for just a moment in personal reminiscence. My first acquaintance with a Petroleum Technologist, and with the Petroleum Industry, dates from before the time of my first association with the Admiralty, and was in the pages of fiction. Those of you who have read that amusing novel by Sir Walter Besant, "The Golden Butterfly," will remember the engaging character of Mr. Gilead P. Beck, the first Petroleum Technologist with whom I had acquaintance. (Laughter.) Although Mr. Gilead P. Beck had the good fortune to strike oil on a very large scale, I always suspected that as a Petroleum Technologist he was not in the first flight, for he admitted that in sinking his first well he had allowed petroleum to the value of £12,000,000 to run to waste (laughter), and it is not surprising that he did not long remain in the industry. (Laughter.) But I recall that some of the opinions expressed by Mr. Beck about the future of the industry, although they were probably introduced by the author in order to provoke ridicule, and they did seem ridiculous enough when the book was published in the year 1875, now read like very modest predictions of what has been actually accomplished by you, gentlemen, and others since that date. Having made the acquaintance of Mr. Gilead P. Beck, it was not many years before I passed from fiction to reality. I well remember that in the early years of this century, not long after I had joined the staff of the Admiralty, one of the great topics of interest to us all was the progress of the trials in H.M.S. *Surly*.

Those trials I think I am right in calling pioneer experiments, which clearly pointed the way to the successful use of oil in place of coal for burning under ship's boilers. About that time also I made the acquaintance of Petroleum Technologists of a very different calibre to Mr. Beck. As a young private secretary at the Admiralty, I had the privilege of meeting Sir Marcus Samuel, now Lord Bearsted, and the late Sir Boverton Redwood. They were both frequent visitors at the Admiralty, and their advice and inspiration helped the Board a great deal in deciding upon the important development of Admiralty policy in the matter of fuel that was then initiated. There are a good many people in this country who, I think, regard the Admiralty as a body that is constitutionally effete and timorous and unable to forecast the future. There is one fact in history that is very well known in the circles in which those people move, and that is that a Board of Admiralty of many years ago strenuously opposed the introduction of steam into the Navy. I should not like to guess how many times in the year, or in how many different connexions, that damning fact is produced, in order to prove that the Admiralty is devoid of prescience and incapable of progress. I think it is almost time that in those circles some attention was paid to the more modern history of the Admiralty in regard to technical developments. I should like them to read the history of the Admiralty's attitude towards the water-tube boiler, or the turbine, and consider whether that history does or does not show a reasonably progressive state of mind. Most of all I should like them to study the history of the Admiralty's connexion with oil fuel, which I venture to say from the outset showed courage and vision in the face of very great obstacles. In fact, from the time that I have mentioned the Admiralty never looked back from the pursuit of the object of converting the coal-burning Navy into an oil-burning Navy, and thereby securing the great advantages of increased speed, improved manœuvreability, rapid replenishment, greater cleanliness, and the reduction of stokehold complements. It is now, as Sir Frederick Black has already told us, only a matter of a very short time before the whole of the fighting ships of the Navy will be oil-consuming. In the meantime we are making steady progress—as rapid progress as financial considerations allow—in the provision of the storage and stocks which the virtual dependence of the Navy on oil fuel postulates. I need not mention in this gathering that one of the chief reasons why it needed vision and courage to make this change of fuel was that it involved supplementing the existing coal bunkering facilities, which had been established gradually and at very great expense all over the world, by large and costly installations. In the Navy estimates of the present year, and of the next few

years, the provision of these stocks, and of these installations is, and must continue to be, a principal and a costly factor. As regards the type of tank and foundation most suitable for naval requirements, the Admiralty gratefully remember that at the outset they had the great assistance and the advice of you, Sir, who now occupy the Chair (cheers), and I may say that, in the main, we are still working on the lines that you then recommended. It will, however, be obvious that the Admiralty, in considering both site and type of storage, have to take into very serious account questions of strategy and vulnerability, and it follows that some of the storage that we are providing is not on lines that would be considered necessary or feasible commercially. I remember that at the time when the question of air attack on this country first became a matter of serious consideration, one of our politicians, a man whose omniscience was sometimes greater than his knowledge (laughter), suggested that a cheap and secure form of storage for oil fuel could be found in disused coal mines. (Laughter.) As far as I remember, we have never been able to make much out of that suggestion (laughter), but at the same time we are doing a good many bold and original things in the way of oil storage. I have just mentioned these points to show you how thoroughly, how completely, the Admiralty are now identified with the progress of the Petroleum Industry. How splendidly the Industry repaid that confidence during the late war, has been told on many occasions, and you will not misunderstand my silence, I am sure, if I do not dwell upon it again to-night. We now see clearly that the lead which the British Navy gave, and which was so quickly responded to by other Navies, in the use of oil fuel is being followed by the merchant navy all over the world. One of the great features of the development in the oil industry since the end of the war has been the increasing use of oil by merchant ships, especially liners. I am told that in the year 1914 only 3 per cent. of the merchant navy of the world, excluding sailing ships, was oil-burning, and the remaining 97 per cent. was coal-burning. But in 1922 the percentage burning oil was 26. I am not sure that from all points of view this particular change is one that is of advantage to the interests of this country, but it does show that confidence in the future of the Petroleum Industry is widespread throughout the world, and that the world looks confidently to you to increase the sources of supply to meet almost any increase in demand. With regard to this question of sources of supply, I should like to say that the Admiralty are quite unprejudiced as to the source from which we draw our oil. We obtain oil at present from Scotland, India, Trinidad, the United States of America, Mexico, Persia and Borneo. Offers of oil from all sources are considered by us, we hope, strictly on their merits,

according to their price, their quality and their geographical position. We welcome every indication of increase in output, of still more extended distribution of the sources of supply, and I need scarcely add, everything that tends towards the elimination of violent fluctuations in price. We also take the greatest pride and pleasure in our uniformly cordial relations with all the great companies with whom we have business relations, regardless of their nationality. It is natural, I suppose, in estimating the progress of the Petroleum Industry and in considering its importance for me to think first of the Royal Navy and next of the Mercantile Marine. But I can quite imagine that many estimable people would say that the provision of fuel-oil for burning under ships' boilers is a comparatively minor and unimportant part of your activities. Navies and merchant shipping, they would say, got on very well burning coal, and in case of need they could very well revert again to the burning of coal. It is in other directions that the different forms and products of petroleum have become indispensable to civilisation, so much so that the progress of the Industry is more a matter for earnest prayer than for mere good wishes. And really, one's imagination is staggered when one thinks of all the ramifications of the present-day uses of petroleum, and of the dire misfortune it would be to all men if oil should cease to flow through these various channels. One thinks of the enormous use of motor-spirit; the immense demand for lubricating oils for every sort of machinery; the innumerable uses of kerosene for lighting and power; and all the other thousand ways in which the products of petroleum have entered into our everyday life, down to their use for the embellishment of our persons and the lubrication of our digestive organs. (Laughter.) In view of all these things, may we not say that the progress of the Petroleum Industry not merely shows us one of the most wonderful examples in the world of business organisation, but has in very truth added a full cubit to the stature of our civilisation, and that in drinking to the further prosperity of the Industry, as I now ask you to do, we are not merely wishing success to a profession, to one race, or to a continent, but are thinking of the welfare of the whole human race? I ask you to drink cordially to the success of the Petroleum Industry, and to couple with the toast the name of Mr. Francis E. Powell. (Loud cheers.)

The toast was enthusiastically honoured.

Mr. Francis E. Powell (Chairman, Anglo-American Oil Company), in responding, said: Mr. President and Gentlemen, I rise with great diffidence to reply to this toast, because it is well known that the men in the petroleum industry are modest folk. (Laughter.) They never advertise. (Laughter.) You never see anything about

them in the newspapers. (Laughter.) You can travel for miles along our highways and never know that they are in business. (Laughter.) My friend, Sir Frederick Black, has referred to the importance of the civilian side of this industry, but with your permission I would like to ask a few questions of our technical friends. I heard Sir Frederick Black say something about the Munitions Department being absorbed by another Department, so that there was no difference between them. I would like the technologists to be absorbed by the civilians so that there would be no difference between us. I would like to say that the great success of this Institution in this country has been emulated on the other side of the water by the recent formation there of the American Institute of Petroleum Technologists. That is an outgrowth of the Oil and Gas Section of the American Institute of Mining and Metallurgical Engineers, and I hope its success will be as great as yours has been.

The history of petroleum dates back for more than four thousand years, and yet to-day we feel the need more than ever of accurate technical information. The only way to get that is for engineers, geologists, and field superintendents to co-operate. If an engineer, a geologist, or an oil operator knows some better way of doing things, or a more efficient way of producing oil, he should have a medium through which that information can be imparted to others. Such a medium is afforded by an Institution such as this, where your members can gather together and discuss with each other items of interest, and can thereby contribute to the knowledge of all concerned.

When we met a year or two ago we were told something about the shortage of supplies of petroleum, and you technical gentlemen were asked to see what you could do to remedy that state of affairs. Well, with a production of 851,000,000 barrels in 1922, which was a gain of 86,000,000 barrels over the previous year, you have done it and more than done it. But there was a miscalculation somewhere—I do not know where it is, and I don't suppose you know. If it keeps on it will be necessary to get the technical side in on the selling side.

Even now, with all this superabundance of supplies, some people are terribly worried about the future. They say the present production is only a temporary and passing phase of the situation, and that we shall soon be as badly off as we were before. I think such people should sympathise with the man who was listening to a lecture on the evolution of the earth. The lecturer said that scientists had calculated that this earth would be cold and lifeless in thirty million years. "How soon did you say that would

happen?" the man asked anxiously. The lecturer repeated the scientists' statement that in thirty million years this earth would be cold and lifeless. "Oh," said the man, with an air of great relief, "I *thought* you said *three* million years." (Laughter.)

When the Pennsylvania operators began to extend their activities to the western part of the United States they stated that their estimate of the saturation of an oilfield was at the rate of 2400 barrels an acre. Those old-timers were the only technologists we had in those days, but with the production of oil which has been going on all over the world by the opening up of new petroleum territories, from Oklahoma to Persia, and from California to Mexico and the East, these old records have been so submerged that they seem positively ridiculous. Now that we have wells producing from 30,000 to 120,000 barrels a day, that historic lore is out of date. Of course, the plethora of oil has its effect upon everybody concerned in the business, not least upon those who have the marketing of the product. Therefore it is that we sometimes hesitate to urge you gentlemen to produce more than you have already done. There is one thing we may be sure of, however, and that is that there is plenty of room in the industry for everybody. We have it on the best authority, that of Mr. Bedford of the Standard Oil Company, that the basis of this industry is so wide, and the opportunities in it are so great, that there is room for all companies and most nations as well.

When I was in Washington last year I saw a very ingenious and complicated model which purported to represent an oilfield in Southern Oklahoma. It was a block pan, drilled with holes, and with slender sticks to represent the oil wells. There was a perfect maze of coloured strings interwoven with the sticks, up and down and sideways, to represent the oil sands. Those 1600 multi-coloured strings gave a very fair replica of the oil-bearing strata, some 1400 to 2200 ft. below the surface, but when that territory is all drilled up and its production known, that mass of sticks and strings will be of very little value for telling what is in other fields.

The fact is, the future development of this business is very much like a closed door. I have read somewhere that the root of all evil is a closed door. This conflicts with what we have been told all our lives, which is that money is the root of all evil, but I believe there really is something in the claim that a closed door is the root of all evil. There is nothing so aggravating as a closed door; it is exasperating; it is disconcerting; it is annoying; it upsets our equilibrium and impedes our days' progress. I do not believe,

however, that if the door were opened you would go through it anyway, but being closed and there being no thoroughfare, you are bound to find a way through, whatever may be the result. Take, for instance, Columbus; he tried to push open a door, which his contemporaries assured him had been permanently closed for good and sufficient reasons. Furthermore, that there was nothing on the other side of it, absolutely nothing, except a chance to fall off into bottomless space—but he pushed the door open, and found—*America*. (Laughter.) Then there was Franklin. He followed flashes of lightning, but met a closed door. He was told to let well enough alone; that nobody knew what lightning would do if let loose; but he pushed the door open and found *Electricity*. And so every Discoverer, every Dreamer, and every Adventurer has had the same experience. If it were not for some of the early door-openers, the world would not have many of the things which add so much to the zest of our life to-day, and among those things is the priceless gift of petroleum. Those early door-openers, such as Col. Drake, Doheny, D'Arcy, to mention only a few, and the present-day technologists, geologists, and wild-catters, which is only another name for discoverer, have added to the sum total of our well-being by their energy and perseverance, and that is the only way in which we have accomplished what we have done in this industry. But these men did not solve all the mysteries. There is a seven-acre field in Glenpool, Oklahoma, that in 1906 had seven wells drilled on it. Those seven wells have been producing ever since, and by old-fashioned pumping methods are still producing 90 barrels a day. Those seven wells have produced altogether, approximately 2,000,000 barrels of oil. There are probably many fields like that around the world, and the question I would like to ask is, How much more oil is there after allowing for the usual percentage of basic sediment? That is a mystery beyond the skill of a layman to settle; a mystery that only a man with scientific and technical knowledge can solve. That is the *closed door* which takes skilled and experienced men to open, and it is to you, gentlemen, and to gentlemen such as you, that we must leave the solution.

Mr. President and Gentlemen, I thank you for the very hearty manner in which you have received the toast of "The Petroleum Industry."

"The Institution of Petroleum Technologists."

Sir Archibald C. Ross, K.B.E. (President, North-East Coast Institution of Engineers and Shipbuilders), in proposing the toast of "The Institution of Petroleum Technologists," said: Mr. President and Gentlemen, I believe the question was asked in this

building to-night by one friend to another: "Why are you here this evening?" He was unable to give an answer. Likewise, Sir, I am quite unable to tell you why I have been selected to propose, what I consider, the second most important toast of the evening, unless it be, Sir, that the Institution over which I have the honour to preside has done possibly more than most Institutions in this country in connexion with the development of the internal-combustion engine during the last two years. In a recent paper which was read by a technologist it was suggested that we might tackle the question of the definition of various types of oil. I hope that our dislike of poaching is appreciated, but we thought that you would be far more capable of dealing with that question than ourselves. My first personal experience of petroleum does not go back 4000 years, as Mr. Powell related, but it goes back some thirty years, when I visited Baku. My second experience was connected with some experiments which were carried out in one of the very earliest destroyers which was fitted for oil fuel, and on that occasion we claimed the credit for having invented the smoke screen. (Laughter.) That took place on the first trial, and although I was personally in charge of the trial, I never got the slightest credit for it. (Laughter.)

The Institution of which I am President, has in the last two years adopted a rule which does not allow of speeches at their Annual Dinner; and in view of the extremely brilliant and eloquent contributions which have been made this evening, I do not propose to vie with Sir Frederick Black and the other speakers in the remarks they have made. I will content myself with saying that if anything warrants the institution of such a society as yours, it is the growing importance of oil fuel and its use. The remarks of Mr. Powell have filled me with joy. Recently I read a paper, which was awarded the Franklin Medal in America, by a very distinguished Swedish scientist, Professor Arrhenius, in which he gave a forecast of the world supply of oil fuel and coal. This was written in 1921. Professor Arrhenius said that, even assuming that the consumption of petroleum is 3 per cent. of that of coal, oil will vanish from the internals of the earth a very long time before the supply of coal is exhausted. But, in view of what Mr. Powell has said, I feel almost inclined to advertise any type of internal-combustion engine. I feel now that we can go ahead and say to every superintendent and shipowner: "If you only realise the amount of oil that you are burning under your boilers (on a ship of the size of the *Aquitania* about 1000 tons a day), and if you will instal internal-combustion engines instead, you can do it for less than 500 tons a day," and then there will be more oil left for your Institution to take advantage of. I think the work this

Institution is doing, and the work which, according to your Report, you anticipate doing, will be of the very greatest value to us, not only, as Admiral Dixon has said, in connexion with heavier and lighter oils, but we shall get some standard by means of which we shall know what we are working with and know what to expect so far as results are concerned. I do not think the work of this Institution is sufficiently well known in this country. I will go so far as to say that if the ordinary engineer or shipbuilder was asked "What is the I. P. T. ?" and he was told it was something to do with oil-fuel or oil, he would say: "Yes, that means the Isherwood Patent Tanker." (Laughter.) Through the courtesy of the President and the Secretary I have been told of the wonderful advance that has been made by the Institution in the past five and a-half years, during which your membership has increased from 188 to 573. "Good wine needs no bush," and it is therefore only necessary for me to say that the work you are doing is of the very greatest value to all those interested in engineering, be it in the Services, in the Mercantile Marine, or in other directions. I therefore ask you, Gentlemen, following Admiral Dixon's example of a four-minute speech, to drink the health of the Institution of Petroleum Technologists, coupled with the name of the President, my old friend, Mr. Barringer. (Cheers.)

The toast was enthusiastically received.

The President, who received a hearty reception on rising to respond, said: Sir Archibald Ross and Gentlemen, In the first place I wish to thank Sir Archibald Ross for the very kind way in which he proposed the toast of the Institution, and you, gentlemen, for the very cordial way in which you received that toast. Before making a few remarks with regard to the work of the Institution I regret to have to announce that, owing to illness and other engagements, several gentlemen who wished to attend the dinner this evening have been unable to do so. Amongst others I may mention that letters have been received from the Duke of Northumberland, the Earl of Durham, Viscount Cowdray, Lord Weir, Lord Bearsted and Sir John Cadman, all regretting their inability to attend, and wishing the Institution every success. I have a list of many names here of other gentlemen who are unable to attend, but in order to save time I do not propose to read it.

Contrary to our usual custom I have been called upon to preside over the Institution at the commencement of my term of office instead of at its completion. I tried to convince our Past President, Professor Brame, that it was clearly his duty to do so, but all my arguments were unavailing, and he being President at the time there was no appeal. Meetings of the Institution have been held

regularly throughout the year. At these meetings very important papers have been read which have led to valuable discussions. The attendance at the meetings has averaged somewhere about 100, which, out of under 600 members, will, I think, bear comparison with any other scientific society with which I am acquainted. A great number of books are now being presented to the Institution for review, which is a great encouragement to us. Our Journal has been most successful, and our Honorary Editor, Dr. Dunstan, is to be heartily congratulated. The sales have increased by 30 or 40 per cent. during the past year, and we now publish four numbers a year. The editor is very ambitious, and this year he is publishing six numbers, and I hope you will all support him by supplying the requisite material. The Institution has also been very active in connexion with the various Committees on which it has representatives. We are now represented on the Committees of the British Engineering Standards' Association, the Imperial Mineral Resources Bureau, the Fuel Economy Commission, the British Association for the Advancement of Science, the Committee of Birmingham University (Students' Department), the 6th International Mining Exhibition, the International Air Congress, the British Empire Exhibition (1924), and two of our members attended the Paris Congress in October last. We hear a great deal about mysterious mixtures of spirit which are going to give wonderful results in the way of propulsion. I think a great deal may be achieved in this connexion by means of research. Lately some very exhaustive tests have been carried out, and the Institution is now considering the question of assisting in the publication of the results, which I believe will be very valuable.

After telling you all these facts about the work of the Institution, you will not be surprised to learn that we have outgrown our present quarters, and, at present, when our numerous Council and Committee meetings are being held, the library is practically out of action. We are now contemplating larger premises, where we shall have much more space for the work of the Institution, including a good room for the Council, one for the members, and a large room for our library, and I am sure the members will greatly appreciate the extra accommodation when it is made available.

As has been mentioned by one of the speakers this evening, the Institution is not yet well enough known. A short time back I was giving evidence in the Law Courts, and in referring to my qualifications, counsel asked me what the Institution of Petroleum Technologists was. I was able to enlighten him as to our activities, and in doing so I mentioned that we dined together once a year, and that I was looking forward to the Annual Dinner being held

within a very short time. (Laughter.) I may say that I did not realise then that I should have to preside. (Laughter.) There is a great deal of ignorance among people in general as to this Institution. A man once asked me what technical petroleum was—whether it was anything like aviation spirit. (Laughter.)

I should also like to inform you that we have seventy students enrolled in our membership, and a very useful lot they are. I am sure that, when they are spread out over the various oilfields and the refineries they will be a great asset to the industry. We hope to be able to place scientific men in these positions, because there is great scope for economy in all the oilfields. The present waste is appalling, and I hope when these students commence their careers they will rectify some of the things that are going on at the present moment. I have tried to get the students to write papers for the Institution, but they nearly always say that they "have not time to do so," but there is generally time to be made at the commencement of the day. I believe there is a saying—I am not sure whether it is biblical or something that was said by one of the old Egyptian kings—to the effect that: "He that calleth upon his neighbour with a loud voice early in the morning shall be reckoned accursed." (Laughter.) Although I have sympathy with the sentiment I am going to risk being accursed by asking for more papers from our students. (Laughter.)

We still have the great benefit that we derive from our Hon. Secretary, Mr. Arthur W. Eastlake. (Cheers.) I am sure we all realise how very much the Institution is indebted to him for his services in every way. (Cheers.) We also have Mr. A. C. Adams as our Financial Adviser, together with the most valuable services of our energetic Secretary, Commander Stokes-Rees. (Cheers.) Under the guidance of these various gentlemen I venture to say that the growth and continued success of the Institution are assured. Thank you very much. (Cheers.)

"Our Guests."

Prof. J. S. S. Brame (Past President), in proposing the toast of "Our Guests," said: Mr. President and Gentlemen, It is my pleasure to propose what I regard as perhaps the most important toast of the evening next to that of the King, namely, that of "Our Guests." This is a very comprehensive toast, and might well always follow the toast of His Majesty, the King, because our guests always include very distinguished members of our fighting forces, of our Civil Service, and of the great Petroleum Industry. This toast being so comprehensive, the whole including all the

parts, it includes all those toasts which we have had before. Custom, however, decrees that the toast of the guests should find the last place on the Toast List. I suppose there may perhaps be some suggestion in that respect that we desire to speed the parting guest. It is a very great pleasure indeed to us to have so many of these distinguished gentlemen present at our annual gathering, but one feels regret to-night that so many whom we would have wished to be present as our guests are unavoidably prevented from accepting our invitation. Our President has mentioned some of the names of those who could not be present this evening; they include Lord Cowdray, Lord Bearsted, Sir Robert Waley Cohen, the Hon. Clive Pearson, and Sir Clarendon Hyde. If you look at a dictionary for the purpose of seeing the definition given for a guest you will find that a guest is described in the first place as "a stranger." Happily, very few of our guests are strangers. Many of them have been present at previous Annual Dinners, and we always welcome them as our friends. Our guests to-night are visitors; they are our friends; and it is our very great pleasure to entertain them at our table. Gentlemen, it is not my purpose to-night to treat of our guests individually, but to treat of them collectively. If I were to spend time in dealing with the merits of our various guests individually I should keep you much longer than you would desire to be kept. Another thing that must be borne in mind is that it has been well said that Daniel was the only man who had been lionised and kept his head. (Laughter.) There is only one virtue, as far as I can see, in deciding that this toast of the guests shall be the last toast of the evening, namely, that it enforces upon the proposer the necessity for brevity. In order that in this case I may give the very distinguished Air Vice-Marshal Sir Geoffrey Salmond time to respond to the proposal of this toast he, like the machines which he has under his control, would require time to rise. Gentlemen, for the aeroplanes which we are all going to have in the near future instead of motor bicycles and motor cars, a certain supply of spirit is necessary. (Laughter.) That, the petroleum industry can, of course, supply. I can only trust that the Institution of Petroleum Technologists has to-night supplied the necessary form of spirit which is required for these flights of fancy, that it has been supplied in sufficient quantity and of the requisite quality, and that it has reached the approved standard adopted by our Standardisation Committee. (Laughter.) Gentlemen, I have very much pleasure in proposing to you the toast of "Our Guests," and in coupling that toast with the names of Air Vice-Marshal Sir Geoffrey Salmond and Admiral Stokes-Rees, the father of our very popular Secretary. (Cheers.) We feel considerable disappointment at the fact that we have not three generations of the Stokes-

Rees family present. We had hoped to have Admiral Stokes-Rees, Commander Stokes-Rees and Midshipman Stokes-Rees present with us this evening. (Cheers.) I give you the toast of "Our Guests." (Cheers.)

The toast was honoured with enthusiasm.

Air Vice-Marshal Sir Geoffrey Salmond, K.C.M.G., C.B., D.S.O. (Air Member for Supply and Research), in responding, said: Mr. President and Gentlemen, I have very great pleasure in responding to what I may say is a very unexpected toast. I had not anticipated the honour of replying on behalf of the guests to-night, and as a modest individual I have great pleasure in passing on that honour to Admiral Stokes-Rees. As the necessity for brevity has been so pointedly mentioned, I would only like to say before sitting down, that as regards the Royal Air Force, which I represent here to-night, nobody recognises more than they do the debt they owe to the Institution of Petroleum Technologists. If it was not for the work that has been done by them in the past, the Royal Air Force could not exist to-day, and it would not have been able to do what it did during the war. Many a time do I remember crises that arose, due to the fact that we were running short of fuel, and not knowing in the least how we were going to get it. But, thanks to your thorough organisation and efforts, our supplies of fuel never failed us in Egypt, where I was responsible for administration and command of the Royal Air Force in Salonica, in Mesopotamia, in Palestine, in East Africa, and in India. (Cheers.)

Admiral W. Stokes-Rees, C.B., who was received with cheers on rising to respond, said: Mr. President and Gentlemen, I have been "told off" to return thanks for the very generous way in which you have proposed and accepted the health of your guests here this evening. I have no doubt that you regret very much that several of those whom you hoped to see here to-night are not present; particularly, if I may mention one name, Mr. Gordon Craig. But you do not regret his absence half as much as I do, because he was to have responded to this toast, and it was only at the last moment that I was asked to do so in his place. Prof. Brame, as an old friend, tried to save me, and coupled the name of Air Vice-Marshal Sir Geoffrey Salmond with the toast. I hoped Sir Geoffrey Salmond was going to take sole responsibility for it. (Laughter.) In the name of the guests I beg to thank you most sincerely for the most charming evening you have provided for us. I was not happy when I heard that I was to reply to this toast. The small amount of courage which I possess very nearly evaporated when I looked at the list of guests and found four closely printed

columns of those for whom I had to reply. I did not consider that I was capable of replying for them. I am told, however, that the list includes our hosts, so that there are not as many as I thought. I notice that among the guests for whom I must reply—and I am diffident about speaking for other people—there are two representatives of the Anglo-American Oil Company. I can only comfort myself in speaking for our cousins over the water by the thought that I have a cousin of my own name, who is also an Admiral, in the American Navy. (Cheers.)

Mr. President and Gentlemen, On behalf of your guests I thank you most sincerely for the happy evening you have given us to-night, and I can only hope that you will ask us all here again. (Cheers.)

During the evening a programme of music was rendered by the British Imperial Orchestra, under the direction of Mr. Arthur Crudge; Miss Edith Penville (Flautist) played some excellent flute solos; and Mr. Stanley Collins performed some conjuring tricks.

The Amount of Undeveloped Oil Land in the Baku District.*

By D. V. Golubiatnikoff.
(Translated from the Russian by T. G. Madgwick, M.Inst.M.M.)

The work carried out by the Geological Committee on the undeveloped oil lands of the Apsheron Peninsula enables them to be classified according to their value as a potential source of oil production. My annual reports (from 1908 to 1917) have been published by the Geological Committee in their "Bulletins," and in order to collect this scattered information and make it accessible I have compiled the present article. As I have already published various articles on the geology of the Apsheron Peninsula and its oil formation, and a recent article (published by "K.I.P.S.,"† at the Russian Academy of Science, vol. IV.) gives all the latest statistics and data, I will confine myself to the economic side of the problem—to a review of our undeveloped oil-bearing lands.

Surakhani.—Owing to its prolific wells this district may be classed among the richest of oil-fields. In 1914 I marked 40 plots for oil development in the northern part of Surakhani surrounding Surakhani Lake.‡ The area embraced by these plots is situated on the apex of the dome of a broad, gently folded anticline, and on its eastern and western flanks, near the apex, the axis running north and south through the centre of the northern "otvod" of Golenishcheff-Kutuzoff, across the XVIII. "group," and through the centre of Nobel's "otvod."

Productive strata occur here at depths from 100 to 360 sagens in the thick productive measures of sand and clay, overlain to a depth of 90 to 100 sagens by clays of the Akchagyl stage. These sands do not form the whole wealth of Surakhani, for they include only the upper and middle series of the upper productive measures; the lower series has not been penetrated by the drill. The total area of these plots is about 228 dessiatines, but to this must be added another 74 dessiatines, consisting of the village lands of Bulbuli, situated north of the plots mentioned and extending as far as the village lands of Romani. Thus we have in all 302 dessiatines. The minimum annual production per dessiatine in this area is estimated at 1,000,000 poods, based on the production of

* This article forms a report made at the request of the Chief Petroleum Committee of the Russ. Soc. Fed. Rep. Sov.

† Research Commission for productive resources of Russia.

‡ See index to the Bulletins of the Geol. Com., from 1882 to 1914, and also D. V. Golubiatnikoff in 1915: "Concerning the auctions of lands for oil production in the Surakhani-Amiradjano-Bulbuli fields."—*Bull. Geol. Com.*, 1914, pp. 374–382 C., 1 Table.

six oil properties in the northern portion around Surakhani Lake in the month of October, 1921, which was 4,279,100 poods. Assuming that the wells were bailed, on an average, 1097 well-days, the daily production per well would be 3900 poods, or a total production per year of 1,400,000 poods, and consequently an average minimum annual production of 1,000,000 poods is not unduly high.*

Therefore 302 dessiatines may safely be assumed to yield a total minimum annual production of 302,000,000 poods, provided that a drilling programme of at least one well per dessiatine, with a rational production from each producing sand, is carried out.

There is also land in the southern portion of this district; *e.g.*, that south of the above-mentioned 40 plots, and extending as far as lat. 40° 24′ 20″, and bounded by the meridians 67° 39′ 30″ and 67° 40′ 30″; *i.e.*, 850 sagens long by 650 wide, or an area of about 230 dessiatines, which has been proved by the wells of the Baku Naphtha Co., Mirzoeff, the Caspian and Black Sea Co., Benkendorff and Mantasheff.

According to information supplied by the Baku Naphtha Co. and Mirzoeff Bros. the production per well is 2200–2300 poods, or 660,000–690,000 poods per year. Therefore, taking a minimum annual production of 500,000 poods per dessiatine, we get an annual production for the 230 dessiatines of 115,000,000 poods.

Thus there is a total of 532 dessiatines of best oil land at Surakhani, which should give annually 417,000,000 poods of oil.

Bibi-Eibat.—Owing to the high yield of its wells Bibi-Eibat occupies second place amongst the oil-fields. The horizons here producing range from that known as X, up to and including XV. The following table shows the production for the month of October, 1921, the most prolific plots being those of Zubaloff (Group XX.) with a production per well of 2628 poods, of Nobel with 1568 poods, several plots of the eighth producing district with about 1013 poods, and the plots of the Caspian and Black Sea Co. (Rothschild), with an average daily production per well of 878 poods.

The plots of Nobel, Rothschild, and Zubaloff fringe Bibi-Eibat Bay, and consequently the southern part of this bay is more petroliferous. Unfortunately, in the reclamation of the bay, no consideration was given to its geology, and the north-eastern part, where the oil-sands are very deep, and judging from the results on plot 27 Bibi-Eibat, are but slightly saturated with oil, was filled in. In all, 54 plots were reclaimed, of which, since 13 in the north-east portion can be disregarded, we have 41, with an area of 170 dessiatines, available. For these we may take a production per well of not less than 2000 poods, which makes the annual production per dessiatine about 600,000 poods.

* D. V. Golubiatnikoff, *loc. cit.*, p. 276.

TABLE SHOWING PRODUCTION AT BIBI-EIBAT FOR OCTOBER, 1921.

Oil districts.	Total production for month. Poods.	No. of well-days.	Production per well per day. Poods.
I.	126,400	275	459
II.	127,960	342	374
III.	387,390	247	1568
IV.	124,600	195	638
V.	159,000	181	878
VI.	728,000	277	2628
VII.	215,300	449	479
VIII.	127,750	126	1013
IX.	83,600	206	405
X.	248,000	458	542

Thus the 170 dessiatines can give an annual production of 102,000,000 poods.

Besides the plots in the Bay there are others in the north part of Bibi-Eibat valley, twenty of which, with a total area of 60 dessiatines, lying nearer to the apex of the dome may be selected. Taking a daily production per well of 1000 poods, judging by the returns for October, 1921, we get 360,000 poods annually per dessiatine, or in all some 21,600,000 poods.

Thus in Bibi-Eibat there are 230 dessiatines of oil-bearing land, capable of yielding 123,000,000 poods annually.

Balakhani-Sabunchi-Romani Field.—This is the old field, producing from 1882 to 1920, inclusive, about 11.2 milliards of poods of oil. Balakhani is the oldest, then comes Sabunchi, and Romani is comparatively new. Up till the present the upper division of the productive measures, 400 sagens thick, has been worked throughout this field, in which the Geological Committee's Survey has proved 34 producing sands. The structure is an anticline striking from Kir-Maku through the mud volcano of Bog-boga, and then turning south-east to the south-east end of the Romani Lake. The beds dip more steeply towards the deeper part of the fold, *i.e.*, from Romani to Balakhani. The lower sands are worked at Balakhani, the intermediate at Sabunchi, and the upper at Romani. The Balakhani series is deeper at Sabunchi, and still deeper at Romani; the Sabunchi series is eroded at Balakhani, and at Romani is deeper than at Sabunchi. Balakhani and Sabunchi are pretty well drilled up and little undeveloped land remains. At Romani there is a large reserve of land.

Romani.—At present Romani must be divided into two, according to its yield; the north-west, embracing all the older plots, and the south-east, where most of the undeveloped land occurs. As may be seen from the table the largest production is from the second oil district, including plots 23, 24, and others.

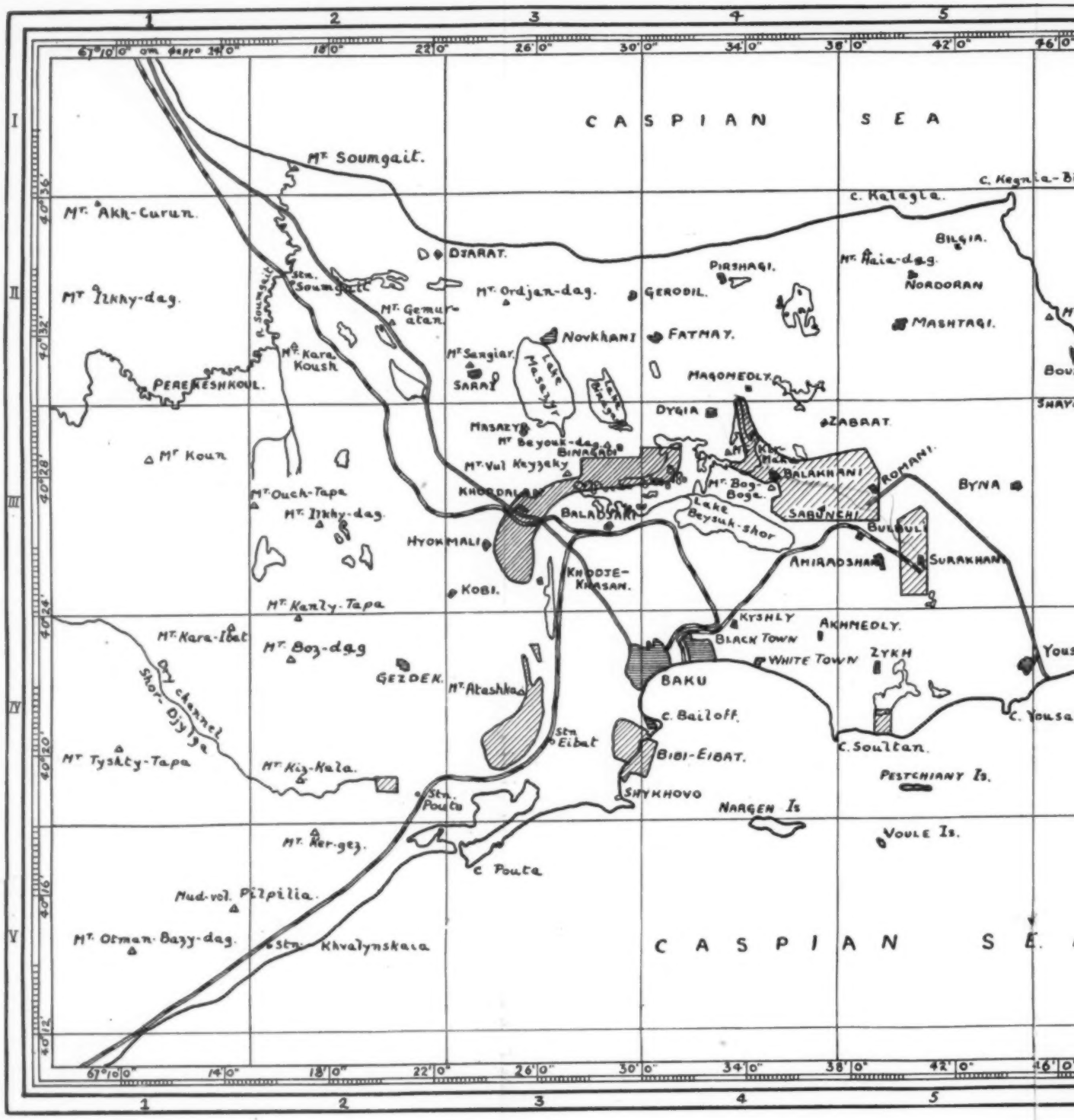
The daily production per well is 1848 poods, and if we remember the high saturation of the Moskow-Kavkazky Co.'s plots, situated on the north-west shore of the former Romani Lake, and after sixteen years' production still giving 401 poods daily per well, then we shall not be exaggerating if we take a daily production per well of not less than 1500 poods for the intervening plots lying in the former Romani Lake, *i.e.*, those between districts I. and II. This area was formerly divided for production purposes into plots as follows: 23 plots numbered 30 to 52; 2 plots numbered 53 and 54, and 9 plots numbered 62 to 70, having a total area of 174 dessiatines. Taking a yearly production per dessiatine of 500,000 poods, the 34 plots could yield annually 87 million poods. In addition, there are plots in the north-east part of Romani, adjoining the producing plots, *viz.*, 19 plots numbered 2 to 5, and 7 to 21, 16 of which, with an area of about 60 dessiatines, are scattered among producing plots which have in part exhausted them. For these an average yield of 500 poods per day may be taken, or 180,000 poods per year. Hence, for a total area of 60 dessiatines we may expect 10,800,000 poods of oil. The remaining plots, numbers 7, 8 and 9, situated on the margin of the pool, where the average production per well may be taken at 1500 poods per day, would give 540,000 poods per dessiatine per year, and with an area of 20 dessiatines a total annual production of 10,800,000 poods.

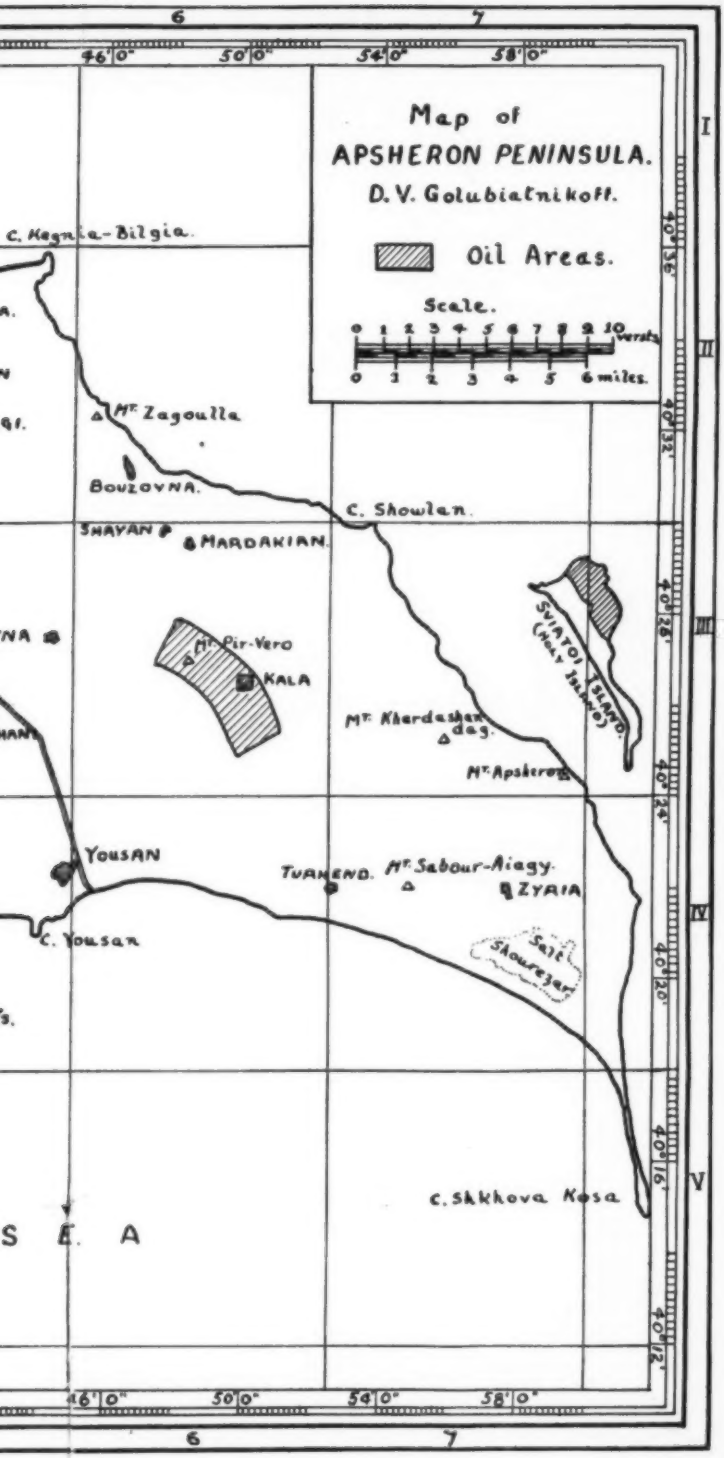
At Romani, therefore, we have in all 53 plots, with an area of 254 dessiatines, which could be relied on to give an annual production of 108,600,000 poods.

Sabunchi.—There are only eight undeveloped plots in the Sabunchi field which are worth testing for oil, numbered 1, 4, and 6 to 11, with an area of 64 dessiatines in the eastern portion, adjoining the Romani area, and 12 plots, numbered 111, 113, 115, 117, 118, 120, 121, 123, 280, 270, and the adjoining land, having a total area of 70 dessiatines, including the Sabunchi Lake. The first eight plots may be taken as giving 1500 poods per day, and assuming an annual production per dessiatine of 500,000 poods we get 32 million poods per year for the whole area. The others would produce 1000 poods per well, or 360,000 poods per dessiatine annually, 25,200,000 poods in all.

Therefore, from the Sabunchi field, 57,200,000 poods would be obtained from an area of 134 dessiatines.

Balakhani.—This is one of the oldest producing areas. The upper division of the productive measures is exhausted, and the only hope of giving a new lease of life is to develop the lower horizons. However, there are seven plots in this field, numbers 12 to 15, and 18 to 20, with an area of 45 dessiatines, situated north-west of Balakhani, and up the dip of the strata, where the lower horizons


CASPIAN SEA
Mt. Soumgait.
Mt. Akh-Curun.
Mt. Ilkhy-dag.
Sta. Soumgait
R. Soumgait
Mt. Gemur-atan.
Mt. Kara-Koush
PEREKESHKOUL.
Mt. Koun
Mt. Ouch-Tapa
Mt. Ilkhy-dag.
DJARAT.
Mt. Ordjan-dag.
Mt. Sangiar.
SARAI
Novkhani
Lake Masazyr
Lake Binagadi
GERODIL.
FATMAY.
MAGOMEDLY
DYGIA
MASAZYR
Mt. Beyouk-dag
BINAGADI
Mt. Vul Kayzaky
KHODDALAR
BALADJARI
HYOKMALI
KOBI.
KHODJE-KHASAN.
Mt. Kanly-Tapa
Mt. Kara-Ibat
Mt. Boz-dag
Dry channel Shor-Dyga
GEZDEK.
Mt. Ateshkan
Mt. Tyshty-Tapa
Mt. Kiz-Kala.
Sta. Eibat
Sta. Pouta
Mt. Ker-gez.
C. Pouta
Mud-vol. Pilpilia.
Mt. Otman-Bazy-dag.
Sta. Khvalynskaia
PIRSHAGI.
Mt. Haia-dag.
NORDORAN
MASHTAGI.
C. Kalagla.
BILGIA.
ZABRAT
Mt. Bog-Boga.
Lake Beysuk-shor
SABUNCHI
BALAKHANI
ROMANI
BYNA
BULBULA
AMIRADSHAN
SURAKHANI
KYSHLY
AKHMEDLY.
BLACK TOWN
WHITE TOWN
ZYKH
BAKU
C. Bailoff.
BIBI-EIBAT.
SHYKHOVO
NARGEN Is.
C. Soultan.
PESTCHIANY Is.
VOULE Is.
C. Yousa
CASPIAN SEA
67°10'0" om Greenwich 14'0" 18'0" 22'0" 26'0" 30'0" 34'0" 38'0" 42'0" 46'0"
40°36' 40°32' 40°28' 40°24' 40°20' 40°16' 40°12'
I II III IV V
1 2 3 4 5


Map of
APSHERON PENINSULA.
D. V. Golubiatnikoff.
Oil Areas.
Scale.
0 1 2 3 4 5 6 7 8 9 10 versts
0 1 2 3 4 5 6 miles.
6
7
46° 0"
50° 0"
54° 0"
58° 0"
I
II
III
IV
V
40° 56'
40° 52'
40° 48'
40° 44'
40° 40'
40° 36'
40° 32'
C. Kegnia-Bilgia.
Mt. Zagoulla
BOUZOVNA.
C. Showlan.
SHAYAN
MARDAKIAN.
Mt. Pir-Vero
KALA
SVIATOI ISLAND (HOLY ISLAND)
Mt. Kherdashen dag.
Mt. Apsheron
YOUSAN
TURKEND.
Mt. Sabour-Aiagy.
ZYRIA
C. Yousan
Salt Shoureizer
C. Skkhova Kosa
S E A

of the productive measures, or the so-called Kir-Maku beds, lie at shallow depth and have already been proved by the drill on adjoining plots to produce 1000 to 4000 poods per day. Taking the minimum average of 1000 poods we get 360,000 poods per dessiatine per year, and therefore from the 45 dessiatines, 16,200,000 poods.

Binagadi.—This is also one of the old fields, but whilst the others were increasing their production Binagadi passed through a period of idleness. Failure to control the water long prevented any production, and it was only in 1908 that the percentage of successful wells began to increase, and the production rose successively each year from 5 million poods in 1908 to 34.6 million poods in 1916.

The field is situated along the broad Binagadi anticline, which widens towards the west to the mud volcano Keireki, and narrows and plunges eastwards into the depression of Bastanor Shor. In the core of the fold are clays of Oligocene and Miocene age, overlain by Pontian clays, with Walensienesia, in turn overlain by the sandy productive formation. The crest is eroded, and the clays with Walensienesia are exposed, the flanks being formed of the productive measures. Dips in the latter on the south side range from 15° to 35°, the lesser values occurring nearer the crest. On the northern side dips are greater, up to 33° to 36°, and the beds are broken by a strike fault, with downthrow on the north side of 68.5 sagens. The fault dies out from Korniuk Shor towards the eastern end of the fold. The work of the Geological Committee has given the following section of the productive measures on the southern flank of the fold (from top to bottom) :—

Series A.	Clay and sandy beds with *Planorbis*	302·5 sagens.
B.	Sandy formation. Sands and coarse-grained sandstones with small angular dark pebbles	114
C.	Unlaminated clays of dark colour, from imperfectly ground material	10·8
D.	E. Sands with thin clay partings	26
F.	Alternating clays, clay sands, and pure sands saturated with oil	66
	Total	519·3 sagens.

Oil occurs in Series B, D, E and F, but the principal horizons are in the lowest series. In this, 29 oil-sands have been recorded, of which 14 are highly saturated; four thick sands are the main source of the production, both by means of hand-dug wells and drilled wells.

There are about 3000 hand-dug pits in Binagadi, which give the bulk of the production; drilled wells, of which there were about 16 in 1912, give less.

The saturation of the beds with oil is irregular, increasing from west to east; *i.e.*, towards the crest at the eastern end of the fold.

The daily production of wells in the western part is about 500 poods, as, for instance, on Stepashkin's property. At the eastern end the production ranges from 700 to 2000 poods per well; *e.g.*, on the properties of Anikst, Djakelli, etc. Of recent years gushers, giving 100,000 poods per day, have not been rare in Binagadi, as, for instance, at the Binagadi Company. The maximum yield of wells may be gauged from Well No. 1 of this company, which, from a depth of 137 sagens, gave about 4 million poods. Other firms obtaining gushers have been Selimkhanoff, Salimoff, Aramazd, the Caspian Society, the Baku-Tiflis Co., etc. Besides these sands in the lower series, those in series B, D and E have been tested by various firms, and some, *e.g.*, Oleonaft, have worked them successfully.

Binagadi oil is of a heavy variety, having a specific gravity 0.913 to 0.925.

A belt of land not yet exploited is situated to the south, south-east, and east side of the Binagadi anticline.

1. To the south is a strip 444 sagens wide and 1268 sagens long, having an area of 234 dessiatines.
2. To the south-east is a strip, 520 sagens by 860 sagens, with an area of 173 dessiatines.
3. On the east side we have 580 sagens by 680 sagens, or 493 dessiatines.

The total is therefore 900 dessiatines. If we take the annual production per dessiatine on the southern side of the anticline as 180,600 poods, we obtain from the 234 dessiatines, 42,120,000 poods annually. For the south-western side the annual production per dessiatine should be taken as 500,000 poods, and therefore the 173 dessiatines should give 86,500,000 poods. For the eastern side, or, more correctly, the eastern end, of the fold as far as the Kir Maku fold, the annual production per dessiatine must be taken as 180,000 poods, and from the 493 dessiatines there would be obtained 88,740,000 poods.

The total from the 900 dessiatines may, therefore, be reckoned as 217,360,000 poods of oil per annum.

Holy Island.—An oil-field exists on Holy Island (in Tartar Pir Allagi), situated between latitudes 40° 21′ 40″ and 40° 29′ 20″ north, near the eastern end of the peninsula, and separated from it by a strait, 4 versts wide, at the north end, and 2 versts at the south. The island lies 40 versts from Baku, in a direct line, and about five hours' journey by steamer. The island extends in the form of a narrow low plain, about 9 versts long, wider to the north and narrower to the south, raised, on the average, some 5 sagens above the present level of the Caspian. The northern end is about

3 versts wide, and contains the oil properties. Holy Island, in the geological sense, stands in direct connexion with the structure of the Apsheron Peninsula, being formed also, like the latter, of Post-Pliocene and Pliocene rocks. To the Post-Pliocene rocks belong contemporaneous deposits of sub-aerial and marine origin, and the deposits of the older Caspian lying unconformably upon the Pliocene. Of the Pliocene there is neither the Apsheron, nor the Akchagyl, nor the upper series of the productive measures present. Only the lower productive measures occur, developed, as on the Peninsula, as sandy clay beds, forming a typical plunging brachy-anticlinal fold, with a strike 339° north-west to 159° south-east, and with flat south-west flank and steep north-east flank, faulted in places. The fold plunges to north-west and to south-east, the beds opening out fanwise from the axis. The northern end of the fold is raised, and since its axis has been denuded the crest appears to have a curved strike turning towards the north-east. The actual crest is eroded in the form of an ellipse with the long axis north-north-west to south-south-east, and having a length of 1.5 kilometre, the minor axis being 230 metres. The fold is broken by a number of strike, dip, and diagonal faults and reversed faults, the northern end being particularly disturbed. It is complicated by two other secondary folds with the same strike, and broken by two important faults with strike of 84° north-east to 104° south-east, and by dozens of smaller ones.

Besides the main fold just described in the north-eastern part of the island, there are portions of the southern end of an anticline striking north-west to south-east, and in the southern part of the island there is a small syncline striking north and south.

Oil Occurrence.—Oil indications consist of oil seepages and gas vents :—(1) On the actual crest of the fold ; (2) along the faults ; (3) in the asphalt-sealed sandstones of the productive measures.

1. Seepages occur on the apex of the dome in the central salt marsh, and at the southern end of the anticlinal, where they occur with gas vents, salt water, and numerous mud springs at the intersection of fault planes. Outside the dome the same fissures show neither gas, oil, nor water.

2. In the eastern and south-eastern parts of the faulted north-east flank of the fold are some copious seepages, deposits of asphalt and springs of mineral water. Here the oil collects in every hollow formed in the Post-Pliocene sands. The deposits of asphalt and the seepages cover an area of about 13.3 dessiatines, the asphalt being worked by primitive means. Tests of the oil-sands of the first and second category gave no favourable results, because no measures were taken to shut off the water.

3. To the third category belong the seepages from the asphalt-

sealed sandstones in the north-east part of the fold. These horizons were tested by wells drilled by Messrs. Nobel Bros., and produced heavy oil from a depth of about 270 sagens. The high angle of dip did not permit of the establishment here of any profitable work, and the area lay idle for a long time. It was only after the discovery, by excavations at the north-east part of the island, of the gentler-dipping beds of the productive measures (dips of 4° to 12°) that steps were taken to prospect further, which gave quite good results. Wells Nos. 3, 4, 7 and 8 had already proved about 8 horizons in 1908 between 130 and 250 sagens. The best oil sources were struck in Well No. 4, giving a gusher with oil of 0.944 specific gravity. The average daily production per well is about 860 poods. During recent years production on the island has increased, as may be seen from the following table of production in millions of poods :—

Year.	Production. Millions of poods.	Year.	Production. Millions of poods.
1904	0·5	1913	4·7
1905	0·4	1914	5·8
1906	0·5	1915	6·9
1907	0·2	1916	7·0
1908	1·1	1917	7·0
1909	1·7	1918	—
1910	1·4	1919	3·0
1911	2·6	1920	3·1
1912	3·3		

The work done by Messrs. Nobel Bros. in recent years has enabled the second gentle fold, striking from north-west to south-east, to be mapped. The south-east end has the beds opening fanwise, and the north-west end is open. The axis is inclined to the south-east. In line with the axis to the north, in the sea, are seepages. According to Messrs. Nobel's work, 19 oil-sands occur in the productive measures, and these beds are exploited by 36 wells, producing from 1907 to 1917, inclusive, about 36.5 million poods. Thus the Holy Island field may be regarded as long since proven, and the saturation of the sands determined. It is well known that the beds of the lower series of the productive measures are oil-bearing throughout the Peninsula, and in the sections of Messrs. Nobel's wells they are recorded as massive oil-sands alternating with unimportant clay beds. The depth of the wells on Nobels' plots varies from 150 to 370 sagens.

From this résumé of the geology it is clear that on Holy Island two anticlines are recorded; a northern, open to the north, and a southern, in the shape of a brachy-anticline. Within the limits of these folds two areas are proposed as proven oil lands.

In the northern anticline production comes from 8 plots with an area of about 40 dessiatines, and situated in the central part along the axis of the fold. There remain unoccupied, and quite worth

exploitation, the south-west and north-east flanks of the fold and its south-east end—in all some 45 dessiatines. The dips on the south-west flank are 24°, on the north-east flank 27°, and at the south-east end, where the strata open fanwise, from 4° to 13°.

The favourable conditions of occurrence, the fact that the geology is well-known, and that the saturation with oil is on a commercial basis, leads to the conclusion that these lands may be regarded as reserves of excellent quality. Taking an annual production per dessiatine of 288,000 poods, we may reckon to obtain from the 45 dessiatines of undeveloped lands about 13 million poods annually. Messrs. Nobel's work has proved 19 sands, which should ensure a minimum life of nineteen years at this rate of production, if a rational exploitation of each sand is carried out.

A characteristic of the Holy Island field is the absence of water, which makes production easier and cheaper. Messrs. Nobel Bros. have found their Holy Island plots more profitable than those on the Peninsula.

The second, the southern, anticline is little prospected, but it deserves most careful attention, since the beds of the productive measures, which form the fold, also contain oil. In the north-east part of the fold a series of oil-sands is exposed, and in the eastern part there are also asphalt deposits over an area of 13.3 dessiatines. Therefore the occurrence of oil on the north-east flank of the fold is beyond doubt.

In view also of the fact that the oil-sands of the lower series of the productive measures are oil-bearing throughout the Peninsula, there are grounds for expecting to find oil also in the sands of the south-west flank, and at the south-east end of the anticline, where the fold plunges and the dips are gentle.

Land favourable for exploitation may be found here to the extent of not less than 213 dessiatines, the belt extending along the strike some 800 sagens, and across it 640 sagens, the western limit being bounded by the intermediate series. Taking the average daily production per well here as from 300 to 500 poods, with a mean of 400 poods, we have an annual production per dessiatine of 144,000 poods. Consequently, from 213 dessiatines we may expect to get a production of about 30 million poods annually. In all, on Holy Island there are 213 plus 45=258 dessiatines, from which a production of 43 million poods may be obtained.

Atashka.—This district was named after Mount Atashka, with its strong gas vents (" Eternal Fires ") on the top of the hill, and seepages and deposits of asphalt scattered over the sides. Rising 120-130 sagens above sea-level, the Atashka ridge is bounded on the west by Kobi Valley, and on the east by the Yassamal Valley, gradually descending southwards to unite with the shore plain.

Through the Yassamal Valley passes the Transcaucasian Railway, with the station Eibat at the south-east spur of the Atashka ridge, the distance by railway to Baku being 20 versts, although only five in a straight line. The precipitous descent from the Baku plateau to the Yassamal Valley prevents a more direct communication with the town. The district, notwithstanding the abundant indications of oil, was long abandoned, and it was only after the Geological Committee had carried out prospecting work, proving the occurrence of many oil-sands, that interest began to be taken in it.

Geological Structure.—At the base of the Tertiary rocks forming this district there occurs a thick series of clays with beds of siliceous dolomitic limestone, containing *Spirialis*, and on this series lie clays with fish remains and shells, apparently belonging to Middle Sarmatian with *Mactra cf. Fabreana*. Above follows a small thickness of clays alternating with thin sands. The clays are overlain by the sandy clay deposits of the productive measures (about 600 sagens thick), in the upper part of which clays predominate with fresh water shells, whilst in the middle the clays alternate with sands, and in the lower sands predominate.

The detailed section of the productive measures was taken on the eastern flank of the hill, and in the Yassamal Valley, by means of a continuous cut, and the entire sandy clay formation may be divided into the following series (from top to bottom).

First Series.—This consists of gray and brown clays with sand beds, the thickness being about 94 sagens.

Second Series.—Is composed of sands and brown clays alternating. The thickness is about 100 sagens.

Third Series.—In this sandy clays predominate, having gray and brown colour. The clays contain seven oil-sands, of which two lie at the base of the series, one having a thickness of 2.7 sagens, the other 1 sagen. The total thickness of the series is about 40 sagens.

Fourth Series.—This is not petroliferous. In it are thick sands alternating with red-brown clays. The sands predominate, and the thickness of the series is about 150 sagens.

Fifth Series.—Sands with partings of brown and gray clay. It contains five oil-sands, and the total thickness is about 26 sagens.

Sixth Series.—This is petroliferous and is formed of thick sands, with occasional sandstone partings and thin clay beds. The top of the series has clean friable sands, about 20 sagens thick, yielding oil indications throughout almost the entire eastern slope of Mount Atashka. The total thickness of the series is about 94 sagens.

Seventh Series.—The upper part of this series, having a thickness of about 19 sagens, is formed of frequently alternating gray clays and sands of iron-gray and reddish-brown colour, and the lower part, with a thickness of about 56 sagens, consists of medium and

coarse-grained sands of yellowish and reddish-brown tints with partings of sandstone and occasional layers of gray clay. The basal sands are coarse-grained, with small pebbles and worn lumps of clay. This series is petroliferous at the southern end of the hill Atashka. The total thickness is about 75 sagens.

Eighth Series.—This may be subdivided also into two divisions, an upper consisting of dark gray clay sands, alternating with clays, about 29.5 sagens thick, and a lower, 18.6 sagens thick, formed of yellowish gray and brown medium-grained sands. At the base occur coarse-grained sands with small pebbles and rounded lumps of clay. The sands carry oil on the southern and western flanks of the fold. The total thickness is about 48 sagens.

Ninth Series.—Formed of clay sands, alternating with thin clays and coarse-grained sands. Medium grained sands stained with oil also contain layers of fine-grained gas-sands. The thickness of the series is about 40 sagens.

The series of coarse-grained sands with small angular pebbles and rolled lumps of clay, having a thickness of 56 sagens, divides the productive measures into two divisions: an upper (series 1 to 6, and the upper part of 7) and a lower (series 8 and 9). In these beds, six oil series have been recorded (3, 5–9) with numerous oil-sands.

Tectonics.—The rocks of the Miocene, the Pontian, and the productive measures, form a sharp anticlinal fold striking north and south, and plunging towards the southern end of Mount Atashka. The eastern flank has dips of 70°–80°, and is frequently overturned. On the western flank dips average 65°. Similarly, where the fold plunges southwards dips range from 15° to 25°. The heart of the fold is formed of much broken Miocene and Pontian clays, which, together with the 9th and 8th series of the productive measures, border the Atashka anticline to the north, at the southern foot of the Shaban Dagh ridge, in the form of an elongated brachy-anticline having a north and south direction, on the eroded crest of which, to the north of the spot where the "eternal fires" are found, a valley known as Berk Dara has formed. Here the whole of the Miocene and Pliocene clays are saturated with oil. The western flank of the fold is broken by a fault with strike north-west to south-east, passing through the "eternal fires" and cutting short the section of the productive measures on the western flank to 35 sagens.

Occurrence of Oil.—Six oil-bearing series have been recorded in the productive measures (3, 5, 6, 7, 8 and 9) with numerous oil-sands, not less than 30, among which are sands up to 20 sagens thick, and oil-bearing throughout the eastern flank of Mount Atashka. The best locality for testing the sands is along a belt about half a verst wide at the north end, and gradually widening

towards the south at the southern end of Mount Atashka, where dips are flatter. On Mount Atashka and its sides the oil-sands of the 5th-9th series are successfully exploited by numerous hand-dug pits. As regards the oil saturation of the sands we may judge by the annual production, which attained 2 million poods in 1913. In 1914 drilling was commenced by Messrs. Safar Alieff, who received one of the best plots for prospecting on the southern flank of Mount Atashka. The first well had a depth of 100 sagens, and "came in" a gusher with about a million poods, the oil having a specific gravity of 0.9. At present there are several wells producing oil from various horizons. In the same district, in the valley of Berk Dara, oil occurs in Middle Sarmatian beds in fissured dark clays crowded with fish remains, in the core of the Atashka anticline. This oil is worked by hand-dug pits, with a daily production of 10 to 100 poods or more, but these are soon exhausted.

In the Atashka district, the entire eastern and western flanks of the anticline have steep dips and there are no localities worth prospecting. Towards the south, however, where the dips lessen and the beds open out fanwise, there is a strip widening southwards, where the dips of the productive measures range from 12° to 25°. The flat and undisturbed attitude of the beds gives very favourable conditions for the development of the Atashka beds of the productive measures. The degree of saturation of the oil-sands has been well demonstrated by many wells and hand-dug pits. From the data thus obtained the average daily production of one well may be taken as 1000 poods, and the average annual production for one dessiatine, therefore, amounts to 360,000 poods.

The area fully suitable for development is equal to 400 dessiatines, which can, therefore, give 144 millions of poods annual production.

Khurdalan.—This district is situated to the north-west of the city of Baku, close to the railway halt Khurdalan, on the Vladikavkaz Railway, on the village lands of Khurdalan, Hyokmali, and Baladjari, and extends as a belt from Hyokmali in the south-west, as far as the Binagadi district to the north-east. This belt is made up mainly of the lower division of the productive measures, containing not less than four workable oil-sands, the overlying intermediate beds consisting of the coarse-grained sands with beds of coarse-grained sandstone containing small angular dark pebbles. The latter do not weather easily, and form a raised ridge, stretching from Khurdalan on the west, towards the Shaban Dagh ridge, and by their sharply-defined lithological character serve as a key horizon.

From Khurdalan to Hyokmali they form an anticline striking north-east to south-west, plunging to the north-east beneath the mud volcano, Zigil Piri, at the village of Khurdalan, and to the

south-west at the ridge of Suli Tepe. Throughout the interval, between Suli Tepe and Hyokmali to Khurdalan, the oil-sands are intensively worked by hundreds of hand-dug pits. Those at the south-western end of the anticline, near Suli Tepe, are especially productive.

The hand-dug pits are grouped around the places named, forming three areas : first, to the south of Suli Tepe, second, in the middle of Hyokmali, and third, to the north-east of Zigil Piri, or more particularly, Khurdalan.

1. *Suli Tepe Area.*—Half a verst south-east of Hyokmali, and one and a half versts south-west of the station, Khurdalan on the Vladikavkaz Railway, the Suli Tepe ridge stands sharply up as an ellipsoidal half-circle, stretching north-north-west to south-south-east, parallel to the neighbouring Shaban Dagh ridge, and separated from it by the Hyokmali synclinal fold. The ridge is formed of the upper layers of the so-called " intermediate " beds of the productive measures, consisting of coarse-grained sands and sandstones, with small pebbles and thin layers of clay. From east and south-east the ridge descends by steep slopes to the head of the Yassamal Valley, where the Hadji Hassan salt marsh lies 107.7 sagens below the top of the hill. Northwards the ridge is cut off by a still steeper scarp at 32 sagens, down to a level of 92.3 sagens above the level of the Caspian, from whence the area occupied with hand-dug pits gradually falls away to the Khurdalan plain. To the north-east the ridge descends gently towards the railway cutting at Khurdalan station. The crest of the ridge turns sharply to the north-west, from the summit of Suli Tepe, and falls by a steep descent to the water tanks of Hyokmali village, thus surrounding the valley as a kind of amphitheatre, facing northwards, where are situated the hand-dug pits of Suli Tepe.

The oil horizons here belong to the lower division of the productive measures, and form a closed ellipsoidal dome, striking nearly north and south, with the major axis inclined to the north-west. The eastern flank dips about 80°, and the western flank about 50° to the west. The major axis of the dome, taking the contour of the coarse-grained sandstone with pebbles, which fringes the oil-bearing series, has a length of 500 sagens, that of the minor axis being 250 sagens. Therefore the area where the oil series is at shallow depth, and is being exploited by hand-dug pits, is 125,000 square sagens, or 52 dessiatines. There are about 50 hand-dug pits in the centre of the area, having depths from 10 to 20 sagens. The production per hand-dug pit amounts to up to 50 poods per day. Besides the 52 dessiatines, an area of 361 dessiatines may be tested on the south-east flank of the Suli Tepe anticline. Consequently, Suli Tepe has a total area of about 413 dessiatines, where the lower

division of the productive measure can be worked, and taking the daily production per well as 500 poods, and the annual production per dessiatine as 180,000 poods, we obtain an annual production from the 413 dessiatines of about 74,340,000 poods.

2. *Hyokmali Area.*—At the western foot of the mud volcano Zigil Piri, the same oil-beds of the productive measures form the north-eastern end of the Hyokmali Khurdalan anticline, the axis of which strikes south-west to north-east. The strata are here covered by the products of the volcano, but the wells drilled by the Russian Petroleum and Liquid Fuel Co. struck them at a depth of about 150 sagens, with a daily production of about 500 poods. The same beds have been worked by a row of hand-dug pits in the Hyokmali area for a long period. The area, which is bounded by the strike of the beds of the Hyokmali-Khurdalan anticline, is about 290 dessiatines, and the production per well may be expected to be 500 poods per day, judging by the results of "Oleum's" wells, and, therefore, an annual production of 180,000 poods from the 290 dessiatines would give us 52,200,000 poods.

3. *Zigil Piri Area.*—This is situated near the village of Khurdalan, 4 verst to the west of the station of Baladjari, on the Transcaucasian Railway, and near the Khurdalan halt on the Vladikavkaz Railway. The area is named from the mud volcano, Zigil Piri, at the western side of which lies Khurdalan. The mud volcano rises 24 sagens above the surrounding country, and lies on the axis of a syncline formed of the beds of the lower division of the productive measures. The Geological Committee carried out prospecting work at the eastern end of the volcano, where the oil series turns, from a strike of north-east to south-west, and a dip of about 45°, to the south-east towards the north-west, making a right angle, and with this strike and a high angle of dip passes off the north-west corner of the plane table sheet to the mud volcano, Kechal Dagh, becoming hidden by alluvial. Zigil Piri Shor (salt lake), situated at the south-east of this bend, gave the following section (from top to bottom), beginning below the intermediate strata formed of the characteristic coarse-grained sands, with coarse-grained sandstone beds, small black angular pebbles, and rounded masses of rock of every age, from Pliocene to Cretaceous :—

(*a*) Sandy clay with 2 beds of sand	23 sagens.
(*b*) Sands with sandstone beds and clays	5
(*c*) Gas-sands with beds of sandy clay	9
(*d*) Bed of sand similar to the sands of the overlying formation. In Binagadi this carries oil; here it is barren..	13
(*e*) Gas-sands mainly mixed with clay	17
(*f*) Oil- and gas-sands with thin clay partings, containing four sands saturated with oil..	26

(*g*) Gas-sands mixed with clay, with water horizon above and below. Also a clay bed with fragmental shells .. .. 9 sagens.

In the actual bend of the oil series are located the hand-dug pits and mud springs emitting oil. In the narrow shor, stretching along the strike of the south-west flank of the series, and beginning at the ravine by the prospect pits, the series *e* and *f* are exposed, with the difference that the gas-sands *e* are here oil-bearing. The total thickness of the oil-series on the south-west flank may be taken as 36 sagens. As prospecting areas the south-western turn of the fold and the eastern foot of Zigil Piri may be recommended. The limits of the area in which oil may be expected are as follows :—

Take 600 sagens along the strike of the beds on the northern boundary, from the axis of the bend towards the east up to the first ravine, and 600 sagens across the strike. The latter distance is taken so that wells located on the southern boundary will be not less than 600 sagens deep. The western boundary of the area is taken through the meridian of the bend, and the southern passes along the strike, and amounts to 950 sagens. We have, therefore, an area of 193 dessiatines, and as we can expect a production per well, judging from that on the neighbouring Baladjari and Khurdalan areas, of 500 poods per day, or 180,000 poods annually, we ought to get 34,740,000 poods annually from the 193 dessiatines when the whole area is in full production.

Baladjari.—Lying to the south of the mud volcano, Keireki, and 2 versts north of Baladjari Station, on the Transcaucasian Railway, this area is formed of the oil-series of the lower division of the productive measures, of the intermediate beds, and of the lower horizons of the upper division, dipping south-east at an angle of 45° on the average, the dip increasing northwards to 55°, and diminishing southwards to 30°. There are hand-dug pits in the north-eastern part of the area, and a sheet of asphalt over about 4 dessiatines. The oil was probably derived from the oil-sands of the lower division of the productive measures, which here make a turn from the north-east to the north-north-east. Where this turn occurs is found the asphalt deposit. On this area there were formed four government "groups," XXI., XXII., XXIII. and XXIV., on which the firms of Sarkisoff, "Spirialis," "Souchastniki," "Neft," Nobel and others have worked. The average daily production per well may be reckoned as 500 poods, and the annual yield per dessiatine as 180,000 poods. The area worth testing for oil adjoins the Zigil Piri area on the west, and on the east reaches to Chakhnagliar on the south-east side of the mud volcano, Keireki. Its northern boundary passes along the strike of the beds underlying the productive measures, whilst the southern runs parallel to it at

a distance of 422 sagens across the strike (assuming the depth of the wells to be about 600 sagens). Therefore, with a length along the strike of 700 sagens, and across it of 422 sagens, we have an area of 123 dessiatines, and with energetic drilling we may obtain 22,140,000 poods annually.

Kala.—Kala is situated 12 versts east of Surakhani, alongside the village of the same name, and long ago attracted attention owing to gas escaping from the depression of a salt lake lying west of the village. The geological structure of Kala is similar to that of Surakhani, and differs from it only in the depth at which the oil-sands of the productive measures occur. This formation is met with at a depth of 200 sagens, whereas in Surakhani its depth is 100 sagens, and therefore the oil-sands which make Surakhani so rich lie here 100 sagens deeper. As has been proved by the work of the Geological Committee the productive measures have a thickness of about 600 sagens, with 32 oil-sands in the upper division (in the section of Balakhani-Sabunchi-Romani), and with 14 oil-sands in the lower division (about 200 sagens thick), as seen in the section of the Kir Maku series. The beds of the upper division are highly impregnated with oil at Surakhani, some 12 versts south of Kala, whilst the beds of the lower division are being worked on Holy Island, the same distance to the east, and thus Kala occupies an intermediate position, and we have the whole productive measures with their 46 oil-sands still untouched. The tectonics of Kala are similar to those of Surakhani and Holy Island, as we have here a flat anticline striking almost north and south, with a bend to the north-west, and where the turn takes place are large gas vents. The wells of A. M. Benkendorff and Nobel give the following section: down to 180 sagens is a thick series of clays with thin sand layers, containing fossils of the Apsheron Stage in the upper part. From 180 to 192 sagens (depths are taken from the log of well No. 2 Nobel) occur black non-calcareous clays at the top, and gray shales with layers of white ash sand below. Underlying these are brown and gray clays with the sand beds of the productive measures. From 50 to 100 sagens slight gas shows were noted in the well; from 100 to 124 sagens stronger shows; and from 124 to 144 sagens still stronger. At a depth of 144 to 158 sagens a slight show of light white oil, with a specific gravity of 0.781 was struck; at 162 sagens—strong gas; at 181 sagens, signs of white oil, and the same was noted at 184 sagens; at 189 sagens there was a blow-out of white oil, with a specific gravity of 0.776. This came from an oil-sand drilled through at 187 sagens. Thus we see that both in the Apsheron Stage and in the Akchagyl gas and oil occur, and as far as the geology is concerned, this district resembles Surakhani, differing only from the latter in the depths of the oil-sands.

The gas-sands in Benkendorff's well were utilised for driving motors. Benkendorff's drilled three wells to depths of 200 to 250 sagens, and in all wells the Akchagyl was encountered and the gas- and oil-bearing strata of the Apsheron and Akchagyl Stages established. In well No. 1, on plot No. II., a gas-sand was found in the productive measures at a depth of 209 sagens, and an oil-sand at a depth of 234 to 236 sagens.

Therefore the same gusher sands which have been developed at Surakhani at a depth of 225 sagens should here be met at 325 sagens. The base of this formation lies at a depth of 700 sagens at Kala. Therefore wells at Kala must be drilled to a minimum depth of 325 sagens, and to a maximum depth of 700 sagens. The area with the best prospects at Kala lies along the axis of the anticline on both sides of the turn of the axis from the meridianal to the north-west direction, with a width of 2 versts, a length of 4 versts, and an area of about 833 dessiatines. From the results at Surakhani it is possible to assess the average annual production from one dessiatine at 500,000 poods by working only one of the upper divisions of the productive measures. Bearing in mind that, besides the upper division, there are 19 sands in the lower division (according to the results on Holy Island) we must reckon that the reserve of oil in the productive measures at Kala, if energetically developed and each sand rationally worked, ought to yield an annual production of 417.5 million poods of oil.

Zykh.—The Zykh district is situated near the village of Zykh, on the southern shore of the Apsheron Peninsula, 5 versts south of Surakhani Station, and 2 versts east of Cape Sultan. The surface geology consists of the beds of the Apsheron Stage, of the Older Caspian Stage, and beds with *Cardium Edule* of the contemporaneous Caspian. The Apsheron rocks form a gentle anticlinal fold, striking north-north-east to south-south-west, and plunging in the south-westerly part of the region. This fold is merely the continuation of the Surakhani anticline. The crest of the fold is much eroded, and there remain the lower horizons of the Apsheron Stage, consisting of clays, in places overlain by limestones of the same stage, and remaining as outliers. Dips range from 6° near the crest, to 12° on the flanks. The beds of the middle and upper horizons of the Apsheron Stage are more denuded on the eastern flank, and are levelled down to a plateau little distinguishable from that on the crest. On the western flank the middle and upper horizons form a ridge, 82 to 72 sagens above the present level of the Caspian, following the strike of the beds. Beyond these ridges the remainder of the Zykh district forms a plain, descending gradually to the sea, and intersected by hollows and ravines among which one especially calls for attention, being occupied by the Zykh salt marsh, 0.5 sagens

below the level of the sea. The bottom of the marsh is covered by a dirty layer of salt, which is worked.

In the structure of the south-east shore of the Zykh salt marsh the deposits of an extinct mud volcano participate. Here we have the rare, if not the only, example of the preservation of the roots or skeleton of a volcano, affording a picture of its internal structure. At some period the mud-flows and ejecta of the former mud volcano were eroded by the Older Caspian Sea down to its base. Among the ruins, traces of the mud-flows have been preserved, together with piles of stones thrown out and all the fissures through which the flows and outbursts took place are exposed. The fissures are filled with the products of a mud volcano, consisting of worked up clay and masses of all kinds of rocks, both as regards lithology and age, among which are sandstones of the productive measures, dolomitic limestones of the Spirialis horizon, and the chocolate-coloured shales with fish remains which underlie the actual Spirialis Beds, *i.e.*, we have in the fissures of this extinct volcano specimens of almost every typical kind of rock from the whole succession entering into the Apsheron Peninsula. From what depths did this outpouring of mud come? In order to reply to this interesting question it is necessary to remember the succession on the Apsheron Peninsula. The clays of the Apsheron Stage, which are rent open by the fissure of the mud volcano, belong to the lower horizons, and have a thickness of about 100 sagens; under them lie the Akchagyl Beds, with a thickness of about 25 sagens on an average, and lower come the productive measures, about 600 sagens thick, and overlying a brecciated rock and diatomaceous and Spirialis beds, some 100 sagens thick. Under these come the Amphisyle shales. Consequently, down to the Amphisyle shales we have 725 sagens, and from such a depth the Amphisyle shales have been ejected, supposing we measure across the succession and assume the channel to have been vertical. The size of the blocks of material squeezed into the fissures is not infrequently more than double the size of the fissure, and therefore at the moment of outburst the fissures must have been much wider than they are now and closed together again afterwards. Masses of rock thrown out during the eruptions are very numerous and of large dimensions; *e.g.*, masses of sandstone up to 1 metre and more in diameter are frequent. Boulders of the Spirialis Beds are so abundant that it almost seems as if we were dealing with the scree from an outcrop of these beds.

The finding of this volcano throws light on the question of the occurrence of oil at Zykh.—An examination of the rocks held in the fissures and thrown out by the mud volcano shows that they are saturated with oil. Thus the sandstones of the productive measures are saturated with oil, and so are the dolomitic limestones of the

Spirialis Beds and the Amphisyle Shales. On breaking the Spirialis limestones, oil is found in the cavities of the shells. These facts enable us to affirm that the productive measures contain oil rocks, and that the oil occurs also in the Spirialis Beds and in the underlying shales. Further, the fact that the shales have been themselves ejected supports the opinion that below the Amphisyle Shales occur rocks saturated with oil, for otherwise we should not be able to explain their ejection from a depth of 725 sagens. *Consequently the question of the occurrence of oil at Zykh is decided in a favourable sense.* The degree of saturation of the beds of the productive measures ought to be determinable by means of a test well not less than 500 sagens deep.

Lying, as it does, some 5 versts south of Surakhani, and forming its immediate extension, the Zykh area is perfectly analogous to that of Surakhani geologically, one of the richest oil-fields. The productive measures on the crest of the fold are overlain at a depth of 100 sagens by the Akchagyl Beds, and the latter by the clays and limestones of the Lower Apsheron. The Akchagyl Beds and the productive measures, judging from the wells, take part in the formation of the flat Surakhani anticline, with north and south direction, continuing as far as the Zykh district, and plunging at the south shore of the Zykh salt marsh.

A strong impulse was given to the growth of interest in the Surakhani field by a gusher of the so-called "red oil," with a specific gravity of 0·814–0·825, from a depth of 225 sagens at well No. 9 of the Baku Naphtha Co. This gusher opened up a new era for Surakhani. Prior to it this district was known as gas-producing, and it was now proved oil-bearing, and production rapidly increased. In 1909 Benkendorff had a gusher from the same stratigraphical horizon, giving about 14,000,000 poods of the same "red oil," and a new big gusher on the Baku Naphtha Co., from a depth of 325 sagens, giving dark brown oil of a specific gravity of 0·840–0·850, settled the reputation of Surakhani as a new prolific field with numerous oil-sands. The test well No. 36 of the Baku Naphtha Co. drilled to 360 sagens, proved several oil-sands, counting from below to the top of the productive measures. At present the following of these are being worked :—

I.	At a depth 96–110 sagens.	At the top of the productive measures	Sp. Gr. 0·776
II.	170–184	About 70–80 sagens below the top ..	0·814
III.	196–200	100–104	0·8205
IV.	256–270	160–174	—
V.	300–325	200–225	0·840
VI.	356–360	244–250	0·860

The saturation of the beds may be gauged from the following

table of production, based on data collected by the Geological Committee in the summer of 1914:—

Horizon.	No. Wells.	Prod. in poods.	Number of days pumped.	Aver. daily prod. per well.
I.	3	469,000	2192	214
II.	30	43,415,793	9981	4350
III.	8	7,810,560	1928	4051
IV.	1	2,000,000	—	—
V.	2	10,737,000	509	21,094
VI.	3	5,055,000	1085	4659

The total annual production at Surakhani in each year was:—

Year.	Production Poods.	Year.	Production Poods.
1904	117,600	1913	40,168,200
1905	25,000	1914	51,879,100
1906	—	1915	60,678,200
1907	344,700	1916	100,900,000
1908	711,200	1917	99,200,000
1909	2,035,400	1918	52,000,000
1910	9,719,800	1919	48,200,000
1911	19,830,100	1920	45,200,000
1912	32,396,000		

As is clear from the data adduced, the Zykh area must be regarded as an oil-field with oil-sands lying at a depth of from 350 to 750 sagens, which determines the depths the wells will have to be. In view of the fact that the degree of saturation of the sands has not yet been determined it is difficult to estimate the minimum annual production per dessiatine. The annual production will have to be got by results of producing wells drilled to the horizons yielding gushers at Surakhani. The number of wells which would have to be drilled in the first year is not less than three, of which one ought to be drilled at the south end of the salt marsh, on the crest of the anticline, and two on the flanks to the east and west, where the dips range about 7°. One well should be taken to the base of the series, here about 750 sagens, with the object of determining the degree of saturation of the sands in the lower division of the productive measures.

All the first wells, being drilled in order to determine the succession and saturation of the beds, must be drilled so as to shut off all waters met with. Samples of the drillings ought to be taken from the actual wells by means of special tools and be examined by expert geologists. The well logs should show everything concerning the well as it is drilled. The area of the ground best suited for prospecting is situated in the southern part of the Zykh salt marsh, where the anticline is plunging, and where the dips are about 7°, and it has an area of about 100 dessiatines, which should ensure an annual production of 36 million poods, taking an average daily production per well of 1000 poods.

Conclusion.

Summary of Oil Lands in Reserve.

Within the limits of the present operating fields we have :—

Old Fields.

Name of Field.	Number of dessiatines free land.	Annual Production. Poods.
1. Surakhani	532	417,000,000
2. Bibi-Eibat	230	123,600,000
3. Romani	254	108,600,000
4. Sabunchi	134	57,200,000
5. Balakhani	45	16,200,000
6. Binagadi	900	217,360,000
7. Holy Island	258	43,000,000
	2353	982,960,000

In all there are 2353 dessiatines, from which it is possible to calculate on a production of 983 millions of poods per year.

New Fields.

Name of Field.	Number of dessiatines free land.	Annual Production. Poods.
8. Atashka	400	144,000,000
9. Suli Tepe	413	74,340,000
10. Hyokmali	290	52,200,000
11. Zigil Piri	193	34,740,000
12. Baladjari	123	22,140,000
13. Kala..	833	417,500,000
16. Zykh	100	36,000,000
	2352	780,920,000

In all 2352 dessiatines, from which can be expected a production of about 781 million poods per year. *The total for old and new fields is* 4705 *dessiatines, with an annual production of about* 1764 *million poods.* To obtain this production it is necessary to drill and deepen 4705 wells every two years.

Within what time can we expect to obtain such a production ? To reply to this the following data require to be considered : the number of productive sands in the field, and the life of the wells working each sand. From the following table will be seen the number of oil-sands as recorded by the Geological Committee.*

* D. V. Golubiatnikoff. *The Oil Fields of the Apsheron Peninsula.* Published by the Research Committee for the Productive Resources of Russia. Academy of Sciences, vol. IV., art. 2, p. 34.

Name of Field.	Number of Oil-Sands in the Productive Measures. Upper Division.	Lower Division.
Balakhani-Sabunchi-Romani	34 Kir Maku, 23 sands over 0·7 sagens thick.†	
Bibi-Eibat	28 (total 55)	
Surakhani	6 oil-sands to a depth of 350 sagens from the top of the productive measures. The beds are as many as in Balakhani-Sabunchi-Romani.	do.
Binagadi	—	29
Atashka	30	—
Holy Island ..	—	19

At Bibi-Eibat the Lower Division has only recently begun to be worked, and judging from the Atashka exposure we may expect to find here another four sands. At Surakhani we have in reserve the whole of the oil-sands of the Balakhani-Sabunchi-Romani field.

Not all sands are uniformly distributed in all fields, nor are they uniformly saturated, and therefore there can be no question of an accurate estimate of the reserves of oil. The total amount of sands is such that it ensures the production for decades in all the fields.

The life of a well per sand is equally not the same everywhere. The minimum is two years, and the maximum is ten years. If we take the minimum life of two years and halve the number of sands then we get that the life of Balakhani-Sabunchi-Romani has an ensured production for 57 years; Bibi-Eibat for 32 years; Surakhani for 57 years; Binagadi for 29 years; Holy Island for 19 years.

These figures can be used to form an approximate estimate of the minimum reserve of oil in the older fields :—

Name of Field.	Annual Production. Poods.	No. of years of life.	Reserve of oil in millions of poods.
1. Surakhani	417,000,000	57	23,769
2. Bibi-Eibat	123,600,000	32	3955
3. Romani	108,600,000	57	6190
4. Sabunchi	57,200,000	57	3260
5. Balakhani	16,200,000	57	912
6. Binagadi	217,360,000	29	6303
7. Holy Island	48,000,000	19	912
Total	982,960,000		45,301

To this must be added the reserves of oil on the properties already producing, having an area of 1400 dessiatines. From the year 1883 to 1921 the total amount of oil produced was 14,192 million poods, which is at the rate of 10 million poods per dessiatine.

† In all there are 66 sands having a thickness of over 0·3 sagen.

The beds of the upper division were those mainly worked, and there remain still those of the lower division, which can give 11,592 million poods of oil. Therefore the total reserves of oil in the older fields are 56,893 million poods. Besides this we have the new fields, with an estimated annual production of 780,920,000 poods of oil.

DISCUSSION on Mr. G. W. E. Gibson's paper,

"Some Practical Notes on Oil Pumping."

Messrs. George Howell and G. Johnston wrote, pointing out the advisability of supplying heat during the pumping of viscous oils, such as that from the Panuco field of Mexico.

Mr. Gibson, in reply, says that it is a pity that the writers did not furnish particulars of the cost of heating viscous oils to temperatures such as 140 to 160 deg. Fahr., say, for an installation in North-West Europe.

REVIEWS.

"The Recovery of Volatile Solvents." C. S. Robinson. Chemical Catalogue Co., New York.

The author, a well-known chemical engineer, is a Professor of Chemical Engineering at the Massachusetts Institute of Technology. His subject is a relatively new one and of considerable importance when one realises, for example, that the whole of the casing-head gasoline industry is but one aspect of it.

The object of the author has been to present in the most simple and concise form the fundamental principles involved in solvent recovery, to discuss the factors entering into the design of works equipment, and to describe standard forms of plant.

The book is divided into six sections. The elementary principles occupy the first six chapters, and therein are discussed gases and vapours, vaporisation, liquid mixtures, distillation and condensation of mixed liquids and vapours, and rate of reaction. The second part handles the application of solid adsorbents, and Patrick's work on silica gel is described concisely. The recovery of vapours by condensation and cooling follows, and the last chapters are occupied with the treatment of cooling and compression processes, and with scrubbing systems. The evaporation of the volatile solvent from the adsorbent and its fractional distillation are not treated, seeing that both these subjects are adequately described in easily accessible literature (W. K. Lewis, *Journ. Ind. Eng. Chem.*, 1921, 427, and Sidney Young, *Distillation Processes and Principles*).

The author's long practical experience in the field of solvent recovery and the co-operative working of a number of leading industrial concerns have led to the production of a very valuable monograph which will worthily fill a notable gap in the chemical engineer's library. A. E. D.

"The Examination of Hydrocarbon Oils and of Saponifiable Fats and Waxes." Professor D. Holme. Translated from the Fifth German Edition by Dr. E. Mueller. Chapman and Hall. 30s. net.

The fifth German edition of this indispensable laboratory companion was delayed till the close of the Great War. This, however, has added to the value of the book in that many important developments in petroleum chemistry were discovered and worked out owing to the exigencies of the times. Substitutes for linseed oil varnish, for resins, for cutting oils, for soaps, and for lubricating oils are consequently described and discussed. New sections on viscosity, the theory of lubrication, colorimetry, turpentine substitutes, wool grease, chlolesterol, and soaps have been written. The wideness of range and the Teutonic thoroughness of presentation render Holde a unique work. Not only for routine determinations, but also as a guide for original investigation, the treatise has been found invaluable in the past and will undoubtedly be so in the future.

The chief chapters deal with the following matters:—General physical tests; general chemical tests; petroleum and petroleum products; natural asphalt; ozokerite; coal, shale, resin, and wood tars; vegetable and animal oils and fats; industrial products prepared from fats; waxes; physico-chemical tables. A very excellent and detailed index is provided. The only adverse comment that can be made is one which, unfortunately, appears

to be common to most scientific publications emanating from Germany, and that is the reluctance to refer to foreign work and workers. As an instance the Lovbond Tintometer is ignored in the section on colorimetry, whilst the very large amount of work carried out in this country on viscometry is scarcely mentioned.

A. E. D.

"Motor Fuels, their Production and Technology." Dr. E. H. Leslie. Chemical Catalogue Co., New York.

This is one of the most valuable and comprehensive monographs that it has been our good fortune to read. It has long been a matter for surprise that the United States, the very homeland of petroleum, has been so apt to let other countries lead in research and publication on a subject so peculiarly her own, but this lapse has been more than made good during the last few years, and an increasing volume of valuable work is being issued. Recently we had the pleasure of reviewing Dr. Brook's masterly treatise on the non-benzenoid hydrocarbons, and the same thoughtful, accurate, and illuminating presentation of a difficult subject is apparent in the bulky volume before us.

Professor Leslie has, in our opinion, done great service to the profession in insisting on the importance of the fundamental laws of physics, thermodynamics, and chemistry. He emphasises the importance of critically examining every process plant and apparatus from this standpoint. Furthermore he has written his book not only for the general practitioner but also for the research student, and he has dealt at length with such basic problems as the thermal reactions of hydrocarbons from the view-point of the practical operator or cracking plants as well as that of the investigator in the University laboratory.

The leading chapters include:—The composition of petroleum; outline of the manufacture of petroleum products; fractional distillation; fluid flow and heat transfer; refinery equipment; thermal reaction of hydrocarbons; cracking processes; chemical treatment of gasoline; alcohol and miscellaneous motor fuels; analysis, and useful constants and data.

The book is singularly up to date, and a careful search has failed to detect the omission of any recent developments, with the exception of the interesting investigations of Bergius.

Needless to say the get-up and printing are worthy of the publishers.

A. E. D.